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QUALITY OF VEGETABLE PARCHMENT WRAPPERS IN RELATION TO THE QUALITY OF BUTTER

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Summary

Parchment paper from a certain source, when used as a butter wrapper, caused development of a rank tallowy flavour on the surface portion of the butter. The paper had high acidity and high contents of soluble copper and iron. The tallowy flavour in the butter was not accompanied by high peroxide and fat aldehyde values. Good quality parchment impregnated with sulphuric acid and with copper and iron salts, gave greater deterioration of the surface portions of the butter than the original parchment and increased the rate of oxidation of the surface of the butter, but did not give a flavour exactly resembling the off-flavour caused by the faulty parchment. The parchment was more fat-permeable, but not more water-permeable, than normal parchment. Indications were obtained that parchment papers containing more than 3 p.p.m. of soluble copper were liable to cause off-flavour in the butter. The limit for soluble iron could with advantage be set somewhat below 6 p.p.m. The methods for extracting soluble matter from parchment have been examined.

INTRODUCTION

The vegetable parchment used for the wrapping of butter in New Zealand has been obtained mainly from British and Belgian sources, and over the period 1930-40 was found to be of reasonably satisfactory quality. During the 1939-45 World War it became necessary to draw parchment supplies from additional sources, which may be referred to here as sources A and C. The paper from source A was found to be of excellent quality and without harmful effect on the surface portions of butter for which it was used as a wrapper. Paper from source C was of very variable quality. When paper from the latter source was used for the wrapping of butter for local supplies many complaints were received from consumers, because of a strong taint on the surface of the wrapped butter. Comparative trials of British and Belgium papers with papers from source C as wrappers for patted butter showed that the taint was definitely due to some fault in parchment from source C, and the work described in the present paper arose out of an attempt to define the cause of the inferior wrapping qualities of this paper.

The methods of analysis used were at first those set out in the British Draft Standard for Parchment for wrapping of Dairy Products, but during the course of the work it was found necessary to re-examine some of these methods. The papers from source C had high acidity, and contents of soluble copper and iron much higher than the limits set for good quality paper in the British Draft Standard Specification. In the course of the present investigation a study has been made of the relationship of acidity and of content of soluble copper and iron in parchment to the keeping quality of the butter for which it is used as a wrapper.

The acidity and the copper and iron contents of good parchment papers were increased by impregnation with sulphuric acid, copper sulphate and ferric ammonium sulphate respectively, and the effects of different concentrations of these additions have been studied.

The values for percentage content of water-soluble substances in parchment may vary with different methods of extraction, and also with different methods of drying the extract. Estimations of soluble copper and iron and of soluble nitrogen and reducing matter are usually made on the water-soluble extract. It is well known that the total copper and iron contents of parchment are much higher than the water-soluble copper and iron contents. Variations in the method of extracting with water may lead to variations in the values for contents of soluble copper and iron in the parchment.

METHODS OF ANALYSIS

Five methods have been compared:—

A. Tentative British Draft Standard Method (1):

"Strips about 2 cm. wide and of any convenient length are folded zig-zag fashion and extracted in a 250 ml. beaker with four successive 100 ml. quantities of distilled water. Each quantity of water is left in contact with the paper at 85-95°c. for 30 minutes." The method thus involves extraction with a total of 400 ml. of water over a two-hour period.

B. Barnicoat's Method (2):

"The paper (5 g.) is cut into strips and soaked in distilled water at 20-22°c. for 14 days and with frequent shaking."

C. Davies' Method (3):

"The paper (5 g.) is cut into strips and soaked in a cold sodium acetate buffer solution at pH 5.0 for 14 days with occasional shaking."

D. Kohler and Hall's Method (4):

"The paper (7.5 g.) is cut into strips as in A, and is transferred to a 500 ml. conical flask, 150 ml. of distilled water are added and the water is boiled under a reflux condenser for one hour. The extract is cooled and 100 ml. (representing 5 g. of paper) are taken for the determination of water-soluble extract."

E. Mummery's Method (for trial purposes only):

"The paper (7.5 g.) is cut into strips as in Method A, and transferred to a 500 ml. conical flask, 150 ml. of distilled water at 20-22°c. are added, and the flask is placed on a mechanical shaker for one hour."

The purpose of the estimation of water-soluble copper and iron is to obtain an index of the probable effect on the quality of the butter wrapped in the parchment, which can be expected to depend on the

amount of copper and iron going into solution rather than on the total copper and iron content. Davies' method involves extraction at a standard pH, but this pH may differ considerably from the natural pH of the parchment or of the butter. Barnicoat's method involves extraction in the cold in keeping with the conditions obtaining during use of parchment as a butter wrapper. Mummery's method ultilizes the same principles as Barnicoat's method but with the use of a mechanical shaker to replace the fortnightly period of soaking. The British Draft Standard method and Kohler and Hall's method are empirical procedures, not intended to simulate actual conditions of use of parchment as a wrapper.

EXAMINATION OF PARCHMENT PAPER

Total Water-Soluble Extract

Drying the Extract:

The weight of extracted material obtained after removal of water varies to some extent with the method of drying the residue. Drying to constant weight at 105°c. as prescribed in the British Draft Standard method causes some charring. To avoid this, Schwarz and Hagemann (5) have recommended redrying the extracted parchment and estimating the quantity of soluble extract by difference. Arup (6) recommended drying the extract at 85-90°c. at a reduced pressure of 120-130 mm. of mercury. The effect of the drying at 105°c. on the extract from the parchment can be expected to vary with the nature of the substances present. Some comparisons of Arup's method with the Draft British Standard method were made on aliquot portions of extracts from a number of parchments. Over 17 comparisons, the results obtained by the Arup method were invariably the higher. The difference varied from 8 per cent to 45 per cent of the value obtained by direct drying at 105°c., average 28 per cent. Arup's method of drying the parchment has been used throughout the present investigation.

TABLE I. EFFECT OF METHOD OF EXTRACTION ON PERCENTAGE OF WATER-SOLUBLE EXTRACT OBTAINED FROM PARCHMENT FROM DIFFERENT SOURCES

Parchment.	Method of Extraction.				
	A. Per cent.	B. Per cent.	C. Per cent.	D. Per cent.	E. Per cent.
1	0·53	0·42	0·59*	0·54	0·32
2	0·89	0·77	0·79*	1·16	0·64
3	0·51	0·45	0·47*	0·46	0·34
4	0·71	0·44	0·51*	0·95	0·62

* After deducting the weight of sodium acetate.

Some results for total water-soluble extract obtained by application of methods A-E to a number of parchments are shown in Table I. The results for the different methods varied much more than the duplicate results for any one method. Method E gave lower results than the others. The results obtained by methods A and D were reasonably comparable.

Content of Water-Soluble Copper:

Results for total and water-soluble copper contents of a number of parchments are given in Table II.

TABLE II. EFFECT OF METHOD OF EXTRACTION ON VALUE OBTAINED FOR CONTENT OF WATER-SOLUBLE COPPER IN PARCHMENT

Parchment Sample No.	Total Copper Content.	Content of Water-soluble Copper in Paper. Extraction Method. A.	B.	C.	D.	E.
	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.
3	32·7	4·7	4·4	4·7	4·7	3·4
4	13·4	1·9	2·2	3·2	1·9	—
5	19·0	3·5	3·7	3·8	4·2	—
6	17·2	4·7	5·2	6·4	4·7	—
7	22·0	6·5	3·6	5·5	7·6	—
8	19·3	7·0	3·9	4·5	9·3	—
9	18·7	5·2	6·9	4·4	8·4	4·4
10	17·7	2·7	2·2	4·0	3·7	2·1
11	9·5	2·6	1·4	2·7	1·9	1·6
Average	18·8	4·3	3·7	4·4	5·2	—

(Copper was estimated, after wet-washing of the paper, and extracted by the thiocarbamate method.)

While method D, viz, refluxing at the boiling point for one hour, gave, on the average, the highest results for content of water-soluble copper, the difference was not consistent and with some papers higher results were obtained by Davies' method, viz, extraction with sodium acetate buffer solution. Extraction at 20°c. for a short time in a mechanical shaker (E) gave consistently lower results than the other methods used.

Content of Water-Soluble Iron:

Results for total and water-soluble iron contents for the same parchments as quoted in Table II, are given in Table III. Iron was estimated, after wet-washing of the paper and extract, by the thiocyanate and amyl alcohol method. Method D, viz, refluxing at 100°c., gave the highest average extraction of iron from the parchments, but the quantities extracted by the different methods were not in consistent proportion. For the purpose of this investigation, method D has been adopted on account of its convenience and efficiency in extracting the soluble copper and iron from the parchment. The method admittedly is open to the objection raised by Barnicoat for all high temperature methods, that the conditions of extraction are artificial and are not related to the

TABLE III. EFFECT OF METHOD OF EXTRACTION OF PARCHMENT ON THE RESULTS OBTAINED FOR CONTENT OF WATER-SOLUBLE IRON

Parchment Sample No.	Total Iron Content.	Content of Water-soluble Iron in Paper. Extraction Method. A.	B.	C.	D.	E.
	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.	P.p.m.
3	287·5	24·0	22·5	34·0	28·0	11·0
4	24·0	3·0	2·0	5·5	6·0	—
5	186·5	15·0	18·5	24·0	26·5	—
6	46·5	30·0	16·0	26·0	34·5	—
7	88·0	32·0	14·5	16·5	32·0	—
8	94·5	22·0	23·5	28·5	46·0	—
9	68·0	26·5	14·5	19·5	34·0	—
10	36·5	3·5	3·0	12·2	5·5	3·5
11	248·5	2·5	1·5	1·7	8·0	7·0
Average	120·0	17·6	12·9	18·7	24·5	—

conditions under which the parchment is used in practice for the packing of New Zealand butter.

Recovery of Added Copper and Iron by Extraction with Water:

Impregnation of parchment was carried out by cutting the material into sheets of the requisite size for wrapping one-pound pats of butter. The wrappers were immersed for one hour in cold aqueous solutions of copper sulphate, ferrous ammonium sulphate or ferric ammonium sulphate in large photographic developing dishes. The wrappers were air-dried at room temperature by suspending from a line stretched across the laboratory. Creases were removed by pressing with a domestic electric iron. Determinations were then made of the total and soluble copper and iron. If the quantities of water-soluble copper or iron were found to be too high or too low compared with the specific amount required, a further quantity of wrappers were immersed in a solution containing a lower or higher content of the metal respectively. For all estimations of soluble copper and iron contents, the parchments were extracted with boiling distilled water for one hour under a reflux condenser according to method D.

Some results are given in Table IV.

TABLE IV. RECOVERY OF ADDED COPPER AND IRON IN PARCHMENT BY EXTRACTION WITH WATER

Parchment Sample No.	Copper (as Copper Sulphate).		Iron (as Ferrous Ammonium Sulphate).	
	Total Copper. (p.p.m.)	Soluble Copper. (p.p.m.)	Total Iron. (p.p.m.)	Soluble Iron. (p.p.m.)
12	399·0	108·5	104·0	6·4
13	84·0	26·2	53·8	3·0
14	41·5	5·5	24·8	1·6
15 (control)	6·8	1·3	5·8	1·8

Parchment Sample No.	Copper (as Copper Sulphate).		Iron (as Ferric Ammonium Sulphate).	
	Total Copper. (p.p.m.)	Soluble Copper. (p.p.m.)	Total Iron. (p.p.m.)	Soluble Iron. (p.p.m.)
16	21·6	8·0	116·5	33·3
17	10·8	5·1	53·8	21·5
18	6·2	2·2	24·8	12·1
19 (control)	6·8	1·3	5·8	1·8

Reference has already been made above to the reasons for selecting method D as the routine method for this investigation. Before this decision was reached, a final comparison was made between this method and method E which provides for shaking at 20°c. for one hour. The results shown in Table V confirm that the cold extraction for a short period gives very low results (see Table II). Reference to Table II shows also that the extraction under reflux, with untreated parchments, gave contents of extractable copper and iron more in keeping with the contents found by extraction in the cold over a long period than did the cold extraction by shaking for two hours. The method of hot extraction

TABLE V. COLD EXTRACTION FOR SHORT PERIOD, SHOWING LOW RESULTS AS COMPARED WITH HOT EXTRACTION METHOD

Parchment Sample No.	Copper Content.				Iron Content.			
	D (refluxing hot)		E (shaking cold)		D (refluxing hot)		E (shaking cold)	
	Total p.p.m.	Soluble p.p.m.	Total p.p.m.	Soluble p.p.m.	Total p.p.m.	Soluble p.p.m.	Total p.p.m.	Soluble p.p.m.
20	20·2	4·8	20·2	1·9	15·4	5·7	15·4	2·6
21	46·7	12·3	46·7	2·9	71·6	20·0	71·6	3·1
22	104·3	32·6	104·3	4·6	97·8	32·6	97·8	3·6
23 (control)	17·7	3·7	17·7	1·3	19·0	4·8	19·0	2·6

under reflux was therefore adopted for the estimation of the quantity of extractable copper and iron in the treated parchments.

Nitrogen and Reducing Matter in Water-Soluble Extract:

Content of soluble nitrogen, like content of reducing matter, can be an index of the amount of total water-soluble impurities present in parchment. Results for some commercial parchment are given in Table VI.

TABLE VI. NITROGEN AND REDUCING MATTER IN WATER-SOLUBLE EXTRACT

Parchment Sample No.	Water-soluble Extract.		Nitrogen.		Reducing Matter.	
	Per cent.	Mg. per sq. metre.	Per cent.	Mg. per sq. metre.	Per cent.	Mg. per sq. metre.
Source A (pre-war)						
10	0·47	329	Nil	Nil	0·06	44
11	0·67	469	Nil	Nil	0·09	63
25	0·42	294	0·01	7	0·14	98
Source C						
9	0·72	504	0·01	8	0·20	140
26	0·72	504	0·02	12	0·25	175
27	0·69	483	0·02	15	0·22	154
28	0·84	588	0·04	25	0·18	126
8	1·12	784	0·05	34	0·22	154
24	0·96	672	0·07	47	0·26	182
4	1·00	714	0·09	63	0·18	126

Two samples of pre-war parchment (Nos. 10 and 11) were found to be free from soluble nitrogen. Arup (6) considers that the major portion of the reducing matter in parchment consists of lignone or lignone decomposition products. The samples from source C did not show a content of these substances appreciably higher than the samples from source A. The results are expressed as percentages in the parchment and also as milligrams per square metre [Barnicoat (2)]. One square metre is the approximate surface area of about twenty-five 1-lb. pats of butter, or two 56-lb. blocks of New Zealand standard dimensions.

Permeability to Fat

Parchment is primarily a grease-proof wrapper. For the measurement of permeability to fat, the turpentine test (7) was used as follows:

A four-inch square of the paper to be tested is placed on a sheet of super-calendered paper of convenient size resting on a smooth plane surface. A smooth-ended glass tube, one inch external diameter and one inch high, is placed vertically on the test sheet and into the tube is placed 5 g. of round-grained sand (passing through a 20-mesh sieve). The tube is removed and 1.1 ml. of coloured water-free turpentine is pipetted on to the sand. The turpentine may be coloured with 1 per cent of du Point oil-soluble red dye or 0.075 per cent of Waxoline Red S (I.C.I.). The time in minutes for the first red stain to appear on the underlying writing-paper is noted. All papers not showing penetration in 60 minutes are recorded as > 60.

Some results of the test on the parchment papers under investigation are given in Table VII. The papers from source C were more permeable to fat (average penetration time, six minutes) than were papers from source A and pre-war British and Belgium papers (average penetration time, 58 minutes).

TABLE VII. PERMEABILITY TO FAT, AND WATER RESISTANCE, OF SOME PARCHMENTS

Parchment Sample No.	Fat Permeability. (minutes)	Water Resistance. (seconds)	Parchment Sample No.	Fat Permeability. (minutes)	Water Resistance. (seconds)
Source C			Source A		
3	7	22	10	>60	45
4	14	26	11	>60	30
7	3	31	25	50	21
9	4	25	35	>60	51
22	7	45	36	>60	38
24	5	25	—	—	—
30	15	33	—	—	—
31	23	23	—	—	—
32	4	30	—	—	—

Water Resistance

Resistance of the parchments to water penetration was estimated by Grant's method (8) viz, "A two-inch square of parchment is sprinkled with a mixture of rhodamine-6 G. and icing sugar, and is floated on the surface of water in an open vessel under an ultraviolet lamp. The time is taken in seconds for the first appearance of pin points of golden fluorescence indicating penetration of water to the dyestuff." Some results of the tests on a number of parchments are given in Table VII. The papers from source C were more permeable to water (average time, 29 seconds) than papers from source A and pre-war papers (average time, 37 seconds) but the difference was not as marked as for fat permeability.

Acidity

Parchment paper should be of neutral reaction. If it has not been properly washed after parchmentizing, the reaction may be acid due to the presence of some residual sulphuric acid. Acidity of parchment has

been measured in the present investigation by the following method (Tentative British Draft Standard, 1). The parchment (3 g.) is cut into strips (5 by 2 cm.) which are placed in a widemouthed glass-stoppered bottle with 100 ml. of distilled water at 90°C. The bottle is shaken for one minute and is then placed in cold water. When the contents are cool, 10 ml. of the extract are removed for the estimation of the pH value. The remaining 90 ml. are titrated in the bottle (without removing the paper) with 0.01 N NaOH to pH 7.0, using bromthymol blue indicator. The results are expressed in terms of H_2SO_4 by weight.

Acidity and pH values of the aqueous extracts of parchments from sources A and C and some pre-war British parchments are given in Table VIII. Butter wrapped in these papers (four pats for each wrapper) was kept in cool store at 40°F. and the flavour of the surface portions of the pats was tested by butter graders each week over a period of four weeks. The parchment papers from source C had much

TABLE VIII. COMPARISON OF ACIDITY AND PH OF SOME PARCHMENTS FROM SOURCE C WITH PARCHMENTS FROM OTHER SOURCES

Parchment Sample No.	Acidity as H_2SO_4. (%)	pH.	Parchment Sample No.	Acidity as H_2SO_4. (%)	pH.
Source C			Source A		
3	0·09	4·5	10 (British)	0·03	6·0
5	0·18	4·0	11 (Belgian)	0·018	6·0
6	0·26	3·8	25	0·01	6·2
7	0·12	4·6	35	0·009	6·4
9	0·19	4·0	36 (Belgian)	0·013	5·0
26	0·10	4·5	40	0·020	6·5
29	0·10	4·2	41	0·008	7·1
28	0·05	4·7	—	—	—
29	0·14	4·3	—	—	—
37	0·08	4·3	—	—	—
38	0·23	4·0	—	—	—
39	0·19	4·7	—	—	—

higher acidities than those from the other sources. They gave a rank tallowy or "oxidized" flavour to the surface portions of the butter for which they were used as wrappers, while similar butters wrapped with British or Belgian parchments and kept under the same conditions were free from taint. The tallowy flavours were different in character from normal tallowy butter. With some papers the off-flavour appeared within one week after applying the wrapper to the butter and was often quite strong after two weeks.

To test the inference from Table VIII that the off-flavour was due to the higher acidities of parchments from source C, the following procedure was adopted:—

Paper known to be of good quality was cut into sheets of wrapper size and immersed in 0.1, 0.5 and 1.0 per cent solutions of sulphuric acid and was then air-dried. The papers were compared with the original untreated papers as wrappers for 1 lb. pats. Four 1 lb. pats were wrapped in each class of wrapper and the butters were held in chill store at 40°F. One pound of the butter in each wrapper was removed from store each week for four weeks. Some typical results are given in Table

IX. The results for peroxide and fat aldehyde tests show that the parchment with high acidity caused a deterioration of the butterfat at the surface of the block of butter.

TABLE IX. EFFECT OF ACIDITY IN PARCHMENT ON THE SUITABILITY OF PAPER AS A BUTTER WRAPPER

Treatment of Paper.	Control - No Treatment.	Treated with 0·1 % Sulphuric Acid.	Treated with 0·5 % Sulphuric Acid.	Treated with 1·0 % Sulphuric Acid.
Acidity of Papers (% H_2SO_4)	0·02	0·16	0·63	1·14
Water-soluble Extract (%)	0·45 (not charred)	0·27 (not charred)	1·01 (charred)	1·54 (charred)
Water-soluble Copper(p.p.m.) and Iron (p.p.m.)	3·2 4·8	4·7 4·8	5·4 5·0	5·7 5·2
Peroxide Test of $\frac{1}{4}$ in. Surface Portion at				
2 weeks	0·40	0·40	0·50	0·55
3 weeks	0·45	0·55	0·65	0·85
4 weeks	0·55	0·90	1·40	1·00
Fat Aldehyde Test of $\frac{1}{4}$ in. Surface Portion at				
2 weeks	0·25	0·20	0·20	0·20
3 weeks	0·90	0·80	1·20	1·60
4 weeks	0·45	0·65	2·60	3·10
Acidity of Fat from Surface Portion (%)	0·17	0·17	0·17	0·22
Grading at				
2 weeks	Good	Good	Not quite as good as 0·1%	Slightly off
3 weeks	Good	Slight off-flavour	Slightly worse than 0·1 % sample	Same as 0·5 % sample
4 weeks	Slight off-flavour	Slight off-flavour	Slightly stronger off-flavour than 0·1 % sample	Same as 0·5 % sample

This deterioration, however, was not very evident to the butter graders, who found it difficult to distinguish the four butters even after four weeks of chill-room storage. The effect of parchment with added acid differed from the effect of parchment from source C in that there was a more definite oxidative effect as shown by oxidation tests, and yet a less definite off-flavour.

It was apparent that the off-flavour in butter resulting from use of paper from source C as a wrapper could not be due entirely to the high acidity of this paper, although it was found that washing in alcoholic

ammonia removed the cause of the off-flavour. It should be noted that high acidity has the effect of releasing more water-soluble copper and iron from the parchment and for this reason also is undesirable.

Effect of High Soluble Copper Content

A high total copper content or a high content of soluble copper in parchment is accepted as a serious fault, but there is little published evidence relating keeping quality of butter to the copper content of its parchment wrapper. Sheets of parchment known to be of good quality were immersed in solutions of copper sulphate of various concentrations and were drained and dried. They were then used for the wrapping of butter (see Table X). Presence in the parchment of 14.2 parts per million of soluble copper thus increased the rate of oxidative deteriora-

TABLE X. EFFECT OF HIGH COPPER CONTENT IN PARCHMENT WRAPPERS ON THE KEEPING QUALITY OF THE WRAPPED BUTTER

Treatment of Parchment.	Control.	Strength of Copper Sulphate Solution Used. (g. $CuSO_4$ $5H_2O$ per 100 g. solution)		
		0·008 %	0·0010 %	0·0020 %
Total copper content (p.p.m.)	6·8	49·5	124·3	175·0
Water-soluble copper (p.p.m.)	1·3	14·2	24·2	52·2
Peroxide test of surface portion of butter at				
1 week	0·30	0·55	0·75	0·65
2 weeks	0·40	0·55	0·95	1·20
3 weeks	0·55	0·55	0·80	0·90
4 weeks	0·60	0·90	0·95	1·25
Fat aldehyde test of surface portion of butter at				
1 week	0·20	0·2	0·20	0·50
2 weeks	0·30	0·35	0·50	0·60
3 weeks	1·00	2·30	2·90	4·20
4 weeks	0·35	2·85	3·40	4·70
Grading :				
1 week	Not tallowy	Sl. tallowy	Sl. tallowy	Tallowy
2 weeks	,,	,,	,,	,,
3 weeks	,,	Tallowy	Tallowy	,,
4 weeks	,,	,,	,,	,,

tion of the surface portion of the butter, the rate of development of the butter and the rate of development of tallowy flavour. The off-flavours developed in butter wrapped in copper-treated parchment were markedly different from those caused by parchment from source C, which, as also shown above, had no appreciable influence on the oxidation tests themselves. A second trial was carried out on parchment paper with a lower range of soluble copper content (see Table XI). These data show that raising the soluble copper content of the parchment from 3.7 to 4.8 made a slight difference in the quality of the butter adjacent to the parchment.

Table XI. Effect of Small Amounts of Soluble Copper Content in Parchment Wrappers on the Keeping Quality of the Wrapped Butter

Treatment of Parchment.	Control.	Strength of Copper Sulphate Solution Used. (g. $CuSO_4$ $5H_2O$ per 100 g. solution)		
		0·00028 %	0·0006 %	0·0015 %
Total copper content (p.p.m.)	17·7	20·2	46·7	104·3
Soluble copper content (p.p.m.)	3·7	4·8	12·3	32·6
Peroxide test of surface portion of butter				
2 weeks	0·25	0·2	0·5	0·60
3 weeks	0·35	0·35	0·45	0·55
4 weeks	0·45	0·7	0·80	0·90
Fat aldehyde test of surface portion of butter				
3 weeks	Nil	Nil	0·20	0·24
4 weeks	0·2	0·3	0·50	0·70
Quality of surface portion of butter after				
2 weeks	Very good	Slightly metallic	Incipient tallowy	Slightly metallic
3 weeks	Slight change	Metallic	Definitely metallic	Tallowy
4 weeks	Slight change	Tallowy	Tallowy	Slightly tallowy

Effect of High Content of Soluble Iron

When parchment paper is immersed in a solution of ferrous ammonium sulphate the iron is taken up by the fibres of the paper and the greater portion of the added iron remains insoluble in water. When ferric ammonium sulphate is used, an increased quantity of the iron absorbed is water-soluble (see Table IV). Papers immersed in various strengths of ferric ammonium sulphate, and then air-dried, were used for the wrapping of butter. Some results are given in Table XII. Increase in soluble iron content not only had a similar effect to increase in soluble copper content in raising the peroxide and fat aldehyde values of the surface portions of the butter, but also had a more definite effect on the flavour, including the rapid production of tallowiness. The results in Table XIII show the effect of increase in soluble iron content over a smaller range.

Increase in soluble iron content from 4.8 to 11.0 parts per million did not cause a marked increase in the extent of oxidation as indicated by the peroxide test, but did increase the incidence of tallowy off-flavour as estimated by the graders.

TABLE XII. EFFECT OF ADDED IRON IN PARCHMENT WRAPPERS ON THE KEEPING-QUALITY OF THE WRAPPED BUTTER

Treatment of Parchment.	Control.	Strength of Ferric Ammonium Sulphate Solution. (g. $Fe_2(SO_4)_3$, $(NH_4)_2SO_4$, 24 H_2O per 100 g. solution)		
		0·006 %	0·012 %	0·025 %
Total iron content (p.p.m.)	19·0	24·8	53·8	129·8
Soluble iron (p.p.m.)	4·8	12·1	21·5	40·5
Peroxide test of surface portion of butter after				
1 week	0·30	0·25	0·25	0·45
2 weeks	0·50	0·80	0·70	1·00
3 weeks	0·70	0·80	0·80	1·40
4 weeks	0·80	0·90	0·80	1·40
Fat aldehyde test of surface portion of butter after				
2 weeks	Nil	0·3	0·3	0·40
3 weeks	Nil	0·4	0·4	0·50
4 weeks	0·2	0·5	0·6	0·80
Grading of surface portion of butter after				
1 week	Good	Tallowy	Strong tallowy	Very strong tallowy
2 weeks	Slight change	Strong tallowy	,,	Tallowy
3 weeks	,,	,,	,,	Strong tallowy
4 weeks	,,	,,	,,	,,

Combined Effects of Added Copper, Iron and Acidity

Parchment sheets were immersed in solutions containing copper sulphate, ferric ammonium sulphate and sulphuric acid to reproduce the average amounts of water-soluble copper, iron and acidity in paper from source C. There were increases in both the peroxide and fat aldehyde values of the butterfat in surface portions of the butter after storage and also marked development of off-flavours; but the flavours were still not comparable with those obtained with use of paper from source C. The results of the butter-wrapping tests are given in Table XIV.

As stated above washing of the inferior paper in alcoholic ammonia removed the cause of the taint. The paper itself had no objectionable natural odour, but steam distillation of the paper yielded a distillate with a definite wood taint but not reminiscent of the taint caused in butter by contact with the parchment. The investigation was not pursued further, since supplies of good quality parchment from normal sources again became available.

TABLE XIII. EFFECT OF SMALL INCREASES IN IRON CONTENT OF PARCHMENT WRAPPERS ON THE KEEPING QUALITY OF THE WRAPPED BUTTER

Treatment of Parchment.	Control.	Strength of Ferric Ammonium Sulphate Solution. (g. $Fe_2(SO_4)_3$, $(NH_4)_2SO_4$, 24 H_2O per 100 g. solution)		
		0·003 %	0·005 %	0·006 %
Total iron content (p.p.m.)	19·0	25·2	33·6	46·2
Water-soluble iron content (p.p.m.)	4·8	6·0	8·0	11·0
Peroxide test of surface portion of butter after				
1 week	0·20	0·20	0·35	0·40
2 weeks	0·20	0·30	0·35	0·45
3 weeks	0·30	0·45	0·45	0·55
4 weeks	0·45	0·45	0·45	0·55
Grading of surface portion of butter after				
1 week	Good	Slight metallic	Slight metallic	Slight metallic
2 weeks	Good	Slight metallic	Slight tallowy	Metallic
3 weeks	Good	Slight tallowy	Definite tallowy	Strong tallowy
4 weeks	Good	Tallowy and metallic	Metallic	Tallowy

TABLE XIV. COMBINED EFFECTS OF ADDED COPPER, IRON AND ACIDITY

Treatment of Parchment.	Control.	Sample.
Total copper content (p.p.m.)	63·0	21·6
Total iron content (p.p.m.)	66·0	116·5
Water-soluble copper content (p.p.m.)	3·0	8·0
Water-soluble iron content (p.p.m.)	5·5	33·3
Acidity (%)	0·02	0·18
Peroxide test of surface portion of butter after		
1 week	0·30	0·10
2 weeks	0·30	0·55
3 weeks	0·30	0·55
4 weeks	0·45	1·00
Grading of surface portion of butter after		
1 week	Good	Metallic
2 weeks	Slight storage flavour	Slight tallowy
3 weeks	Slight storage flavour	Strong tallowy
4 weeks	Slight storage flavour	Tallowy

Conclusion

Although the cause of the off-flavour on the surface of butter wrapped in paper from source C has not been defined, the results obtained in the course of the investigation are of value as they indicate in semi-quantitative terms the effects of soluble copper and iron in parchment on the quality of the surface portions of butter. The limits for soluble copper and iron contents of parchment, fixed by the British Tentative Draft Standard, are three and six parts per million respectively. The results obtained in the present investigation would indicate that the limit for the amount of soluble iron could with advantage be lowered. A lower value for soluble iron, however, may not be readily obtainable under the present system of parchment paper manufacture. The results for total copper and iron content have been found to bear no direct relationship to the quality of the parchment for butter-wrapping purposes.

Acknowledgments

The authors wish to express their thanks to Messrs. J. A. Singleton and J. J. O'Dea for assistance with the butter grading.

References

(1) British Standards Institution (1939): Draft Standard Specification for Vegetable Parchment for wrapping of Dairy Products.

(2) Barnicoat, C. R. (1938): *N.Z. J. Sci. and Tech., 19,* 563.

(3) Davies, W. L (1934): *J. Soc. Chem. Ind., 53,* 117T.

(4) Kohler, S. and Hall, H. (1925): *The Paper Ind., No. 7,* 7.

(5) Schwarz, G. and Hagemann, B. (1941): Vorratsphlege und Lebensmittelforschung, *IV,* pt. 5-6.

(6) Arup, P. (1931): *Analyst, 56,* 149.

(7) Anon. (1942): *Paper Trade J., 114* (16), 33.

(8) Grant, J. G. (1934): *J. Soc. Chem. Ind., 53,* 349T.

SOIL CONSERVATION STUDIES APPLIED TO FARMING IN HAWKE'S BAY

PART IV. INFLUENCE OF FARMING ON SOIL EROSION

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Summary

In order to place the soil erosion problems and conservation needs in correct perspective and appraise the extent to which farming has altered the balanced operation of the components of the landscape it is necessary to analyse the changes which burning, grazing and cultivation have caused, and how they have interacted with parent material, soil, slope, climate and vegetation to accelerate the erosion processes.

A synthesis of what has happened provides information from which conservation principles can be deduced.

Brief History of Land Utilization

For several centuries prior to the coming of the Pakeha the Maoris had developed extensive settlements throughout Hawke's Bay. Their needs were simple and their demands upon the land limited, but extensive fires reported in their history would account for the absence of coastal forest in many parts and the charred totara logs found far inland in the early days.

It is worthy of note that before trees or food could be taken by the Maoris their supreme deity, Tane Mahua—God of the Forest—had to be propitiated; "tapus" or prohibitions were placed on various parts of the forest at various times. In this way conservation of food and forest resources were woven into their highest religious ethics. The signing of the Treaty of Waitangi in 1840 signed away conservation in return for civilization.

Rhodes as early as 1841 drew attention to the potentialities of the Hawke's Bay province. The early settlers brought their flocks and herds inland from the coast and north from the Wairarapa and settled on the natural grasslands. By 1865 sheep had been introduced. The province was taken up in large holdings which remained as such till the '80's and '90's.

The rank native tussock grasses and swamp plants were burned to provide shorter and more suitable sheep feed and the flat and gently sloping lands were extensively cultivated. As the demand for more stock feed grew, the extensive bracken-covered rolling hills were burnt and surface-sown with mixtures of English grasses and clovers. A technique known as "crushing" (37) was evolved to prevent the regeneration of fern. (The areas being treated were very heavily stocked with sheep and cattle in October-November when the fern fronds were tender and relatively palatable.) On shady and steeper slopes where the grass was difficult to establish, repeated burning and "crushing" was necessary to subdue the fern.

A similar method was used to prevent the regeneration of forest on land that had been partly felled and fired in the early autumn. Remarkably good swards of English grasses and clovers sown on the ashes were obtained and subsequent heavy grazing by cattle and sheep was necessary to control "second growth".

Fluctuating prices, droughts, overstocking for fern control and increase in the speculative values of land led to over-grazing and the poorer country was invaded by *Danthonia* and manuka scrub. This deterioration and the high cost of manuka control has resulted in marginal land being abandoned.

The overgrazed swards frequently deteriorated exposing the soil to sheet and wind erosion, and drying out that led to cracking and later, when the rains came, to slipping.

Not only did the hill country suffer from periodic droughts and erosion by torrential rains but earthquakes released simultaneously the normal mass movements of a century or more.

Cropping on the central plains partially exhausted the lighter soils, structure disintegrated, and wind erosion caused severe losses. " Blown " fields were a common threat, particularly on the Ruataniwha Plain, and extensive plantations (largely *Pinus radiata*) were established to reduce the hazard.

In a recent paper Taylor (38) has shown that approximately half of the land in the Hawke's Bay Land District is class 6 land which Grange (39) describes as " hilly or steep land which has severe limitations to utilization, such as low fertility or erodibility and is probably more suited to forest than to grass ".

Although pastoral farming is the dominant type of land in use a portion of the ploughable land on most holdings is cropped for supplementary feed, and relatively small portions of the heavy alluvial land are used for intensive farming, i.e., orchard production and market gardening. The following statistics were obtained in 1945 :—

A. *Condition and Tenure of Land.*

Freehold	1,768,199 acres
Leasehold	958,073 acres
Unoccupied	199,261 acres
Total	2,925,533 acres

B. *Unimproved Occupied Land.*

Standing Native Bush	97,218 acres
Phormium	153 acres
Tussock and other Native Grasses	399,451 acres
Fern Scrub and Second Growth	256,099 acres
Barren and Unproductive	38,294 acres
Total	792,025 acres

C. *Orchards.* 3,002 acres

D. On the Occupied Land the following stock are carried :—

Horses.	Dairy Cows.	Total Cattle.	Sheep.	Pigs.
14,700	50,151	348,264	4,541,337	16,786
5·3	18·3	127·7	1665·9	6·1 per thousand acres.

FARMING PRACTICES AND INFLUENCE ON SOIL EROSION

Since clearing, burning, grazing, and cultivation have singly or in combination induced soil erosion, their effects are of paramount importance.

(1) *Clearing or Felling of Native Plants*

Clearing and felling have necessarily been widely practised to win farms from virgin land. Removal of plants interferes with the direct entry of water to the soil via the stems and roots and exposes the litter to wind, frost and sunshine. Even at this stage native plants regenerate effectively but burning, cultivation or grazing usually follow clearing and are responsible for greater damage. The clearing of natural cover from very steep areas has proved to be hazardous owing to rapid soil removal. From a slope at Tangoio that was felled, burned and sown two years prior to the 1938 flood, the surplus water ran dark brown in colour from the hillside during the flood. The surface soil was completely washed off in places and the clay exposed, while shallow slips were common on the steeper slopes. On the rolling-to-steep coastal country numerous slips have scarred pasture land won from forest.

At Ashley Clinton, where thirty years ago beech, matai and rimu forest held the soil, good strikes of grass were obtained after felling and burning, but the severe grazing necessary to suppress bracken fern resulted in poor swards on the windward and sunny slopes where sheet and wind-eroded patches developed from terracettes. Subsequent removal of two to four feet of soil is fairly common and the shattered greywacke collects to form a protective pavement or running scree according to the slope.

The destruction of native plants marks the first stage of deterioration, which may, or may not, be arrested by sown pastures. Bailey (40) found geological evidence proving that the destruction of vegetation was the principal cause of accelerated erosion. MacDonald Holmes (41) regards vegetation as a "society of plants and that destroying some members of the society interferes with the future life history of the remainder, though they may not actually be touched."

(2) *Burning*

Burning was the most widely used and effective means of winning farm land from native bush, fern and scrub, while native tussock grasses were burnt regularly to force the growth of palatable shoots, and subsequent severe grazing killed them. The smaller grasses that grew among them died as the protective tussocks disappeared.

Much of the land of Kaweka Ranges, once famous for the abundance of bluegrass (*Agropyron scabrum*) has been abandoned owing to the folly of one owner who burned the native grasses regularly. The area has reverted to manuka scrub, active screes and discontinuous patches of severely eroded clay on the leading ridges and sunny slopes.

Used judiciously on bush, scrub and fern country, and followed up by surface sowing, fencing and dominantly cattle grazing, burning proved to be a most important technique in "breaking in" the land. It was such an easy and effective method of controlling fern and second growth on poor land that repeated burning rather than good husbandry

practices were used after the original burn. Regenerating bracken fern was controlled, but fertility declined rapidly and manuka scrub invaded the weak, fire-induced *Danthonia* swards.

Experience proved that manuka could not be controlled cheaply by burning—but had to be slashed—consequently manuka-invaded hill country was increasingly abandoned or burnt, and further exposed to wind and sheet erosion (37).

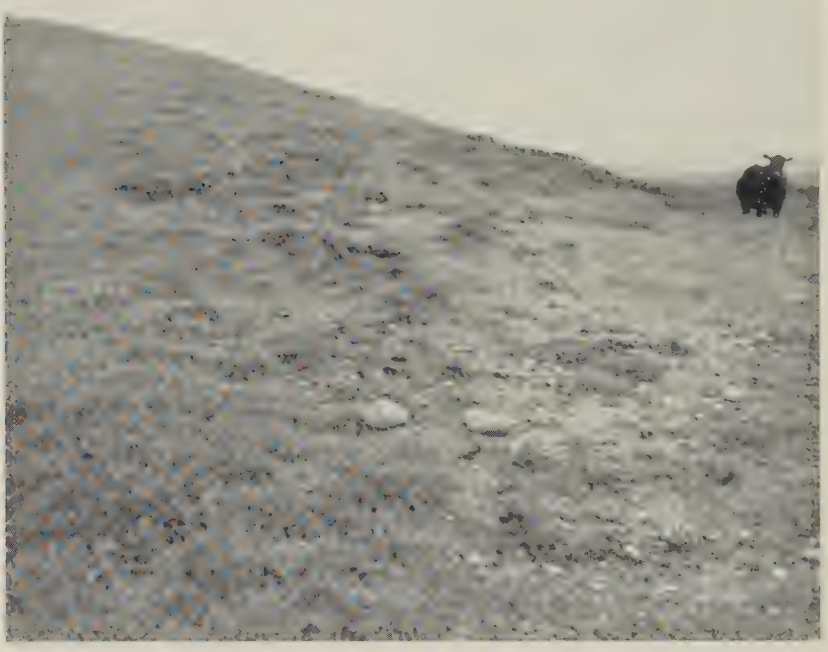

Fig. 47.—"Balds" from which the soil has been removed by sheet erosion, aided by cultivation and stock movements, Sherenden.

Fire, under very dry conditions, burns all the litter on the surface, and in native bush it travels slowly, burning the litter and organic matter in the soil, to leave raw, red-tinted mineral soil exposed. Bereft of the surface litter and vegetation, frequently burnt-over soils became compacted, the surface openings clogged by fine loose particles (10) and the infiltration capacity declined with the result that run off and soil loss increased.

Clapp (32) states that "forest fires in pine-hardwood forest increased surface run-off 10 times over unburned forest of the same type and as much as 32 times in individual storms . . . in Sierra pine region a five-year record shows that surface run-off from repeatedly burned plots was 31 to 463 times as great as that from unburned forest." According to Chapline (42) "of all the man-caused erosion, that resulting from fire has probably been the worst."

(3) *Trampling and Grazing*

Trampling and grazing work hand in hand; the former destroys the vegetation and consolidates the soil while the latter destroys vegetation by defoliation. The sharp edges of hoofs cut and dislodge soil under dry conditions, and poach it under wet conditions. The damage done by trampling is directly related to the fodder available as hungry animals travel excessively.

Farming experience has shown that native grasses will withstand moderate grazing successfully, but overgrazing is ultimately inimical. Droughts, overstocking during the winter months and the prevalence of rabbits have all contributed to overgrazing in the past. Severe grazing is so damaging to vegetation that it has been adopted to control bracken fern, second growth bush, manuka scrub and piri-piri in order that grasses may compete successfully with them.

On the eastern end of the Burns Ridge, Kuripapanga, a sequence from healthy *Danthonia rubra* and *Festuca novae-zealandia,* through the intermediate stages of depletion caused by burning and grazing, to bare eroding clay, and finally a rock pavement is indicative of what damage can be wrought by excessive grazing and burning.

Severe grazing of mixed and inferior pasture plants on poor soils results in the survival of less nutritious plants and invading weeds. As little or no organic material is returned to the soil there is consequently a progressive decline in its fertility (43). This decline is manifested in reduced carrying capacity, deterioration of pasture, increase of fern, scrub and second growth, and the formation of actively eroding areas (44). (Fig. 47.)

Even where good farm management maintained permanent pasture, excessive trampling and grazing increased surface run-off. Experimental results indicate that the grazing management of pastures is a very critical factor in governing the loss of water and that poor pastures contribute to accelerated erosion in no uncertain manner.

Deer, goats, and cattle indirectly destroy the litter and surface roots of forest trees, and directly damage such trees as mahoe, five-finger, broadleaf, Hoheria spp., and all seedlings. In many forest areas deer and goats have completely cleared the forest floor and the rooting of wild pigs keeps the thin soil and underlying shattered rock on the move downslope into the already overburdened streams. Cockayne (45) studied the native forests before and after the introduction of deer and declared that the change on the forest floor and in the undergrowth was almost beyond belief.

(4) *Cultivation*

Ploughing and subsequent consolidation of soil in order to grow crops is an important cause of increased run-off and soil loss. According to Lowdermilk (46) "continued cultivation, though so necessary, often contains the seeds of its own destruction." The breaking down of soil structure, loss of organic matter and increased run-off due to continued cultivation were indicated in Part I where it was shown that cultivation is the most potent farming practice in accelerating soil loss.

Soil loss on continuously cultivated sloping vineyards has been severe —on three vineyards from eight to eighteen inches of soil have been lost by creep and sheet erosion during a period of from twenty to forty years

(Fig. 48). Throughout the province there have been sufficient examples in the past of severe sheet and rill erosion to give convincing evidence that heavy rain will erode much of the soil from fields cultivated to a fine tilth. Soils are particularly susceptible when sown to crops or when disced after such crops as rape. Several cases of severe sheet and rill erosion indicate the hazard, while further inland strong winds are an even greater hazard, and examples of "blown" fields are legion. Fields recently ploughed and cultivated from pasture were much more resistant to sheet and rill erosion than those under continuous cultivation.

Fig. 48.—Exposed grape vine roots indicate losses of soil by sheet erosion and soil creep, speeded up by cultivation, Havelock North.

Near "Blowhard" on the Napier-Taihape Road an area of twenty acres of late sown spring oats was "blown" in 1917 and the surface soil was removed. Subsequently, wind and water have removed two to four feet of volcanic soil, and the bare, smooth surface during summer contrasts sharply with the layer of structureless material loosened by frosts during winter. To the leeward, mounds four feet in height, growing Chewings fescue, were found to be windblown sand held by a living network of fescue rhizomes throughout the full depth.

The reduction in cropping (oat growing particularly) has led to short rotation cropping which has done much to minimize losses in many areas. Periodic cultivation of gently sloping and flat loams of good structure is fairly safe, but continuous cultivation is hazardous on sandy soils in windy districts.

Productivity Trials

Productivity trials showed that soil loss was reflected in diminished yields, examples of which are given below for vineyards at Havelock North.

Vines on the crest of the hill in a ten year old vineyard were standing well out of the soil with two or three larger lateral roots exposed for a distance of 10 to 15 in. from their point of origin. On the lower part of the slope, buried vines and posts indicated at least 9 in. of increase in soil depth. The vines progressively improved in vigour, size and productivity down slope. Six representative rows were chosen at regular intervals along the slope, and the yield of the top eight and bottom eight vines in each row determined:—

Average Yield of Vines Along Crest of Slope. Weight in lb. per vine.	Average Yield of Vines Along Base of Slope. Weight in lb. per vine.
Mean Yield 6·4 ± ·47 lb.	9·6 + 1·1 lb.

The field was ploughed during the previous winter and sown to rape in October. Examination of the field in January revealed uneven patches and a general decline in production as the slope increased, to the extreme stage on steep faces and knobs from which the entire soil had been removed. On 5° to 10° slopes the mean yield of 20 average plants was 150 g. On slopes over 20° the mean yield of 20 plants was 25 g. On steep slopes and bare knobs the mean yield of 20 plants was 3 g. On flat and gently sloping areas the mean yield of 20 plants was 300 g.

This area was an even slope of Matapiro soil at Napier and had been under cultivation for a number of years. The rows were planted across the slope with certified Arran Pilot seed in June, treated with superphosphate (3 cwt. per acre) and dug on 30 October 1937.

Yield per plant on lower portion of slope. in oz.	Yield per plant on lower crest of slope. in oz.
Mean 21 ± ·4	8 ± ·3

Productivity trials indicated that loss of soil caused decline in production on steep cultivated slopes. Similar decline in production of herbage on steep grassland is frequently observed. In extreme cases the complete removal of the topsoil causes production to decline to zero.

(5) *Drainage of Swamps*

The drainage of large swamps removed from the river systems an important flood control device—the temporary storage of surplus water. Probably more important, however, was the extermination, by drainage and grazing, of niggerhead, flax, rushes and manuka in the headwaters of practically every small stream. Along the banks, and in the beds of streams, these plants also assisted in delaying the passage of floodwater.

According to reliable observers, flooding in the Tukituki River was not serious until the large swampy areas of the Ruataniwha plains were drained. The Kumeti Drain between Dannevirke and the Ruahine Ranges is a more recent example. Several years ago an area of swampy forest land at the foot of the ranges was drained in order to clear and farm the area. Later heavy rains caused scouring which made a channel ten to twenty yards wide and several feet deep (Fig. 49). Subsequently weirs were placed across it to prevent the shingle from travelling down

FIG. 49.—View of Upper section of Kumeti Drain.

the channel, but in a short time the shingle completely filled the channel and an intermittent stream that menaces valuable farm land downstream now flows over the shingle.

INCIDENCE AND EXTENT OF SOIL EROSION

Incidence of Erosion in Mid-Hawke's Bay

The incidence and extent of soil erosion is closely linked with the physical factors of slope, soil, and climate, hence the need to deal with the natural regions of the area individually.

The following tables were taken from a report by Pohlen *et al.* (47):

DISTRIBUTION OF EROSION ON SOILS OF THE RANGES.

Soil Series.	Area in Acres.			
	Total.	Little erosion.	Eroded complex.	Severely eroded.
Ruahine	101,856	61,664	23,708	16,484
Kaweka	91,493	12,305	72,485	6,703

DISTRIBUTION OF EROSION ON MID-HAWKE'S BAY SOILS.

Degree of Erosion.	Proportion of surface area eroded.	Area in Acres.	Percentage of Total.
Very severe	Over 30 per cent.	31,105	2·6
Severe	20 - 30 ,,	179,144	15·3
Medium	10 - 20 ,,	83,345	7·1
Slight	1 - 10 ,,	318,219	27·1
Nil to Slight	0 - 1 ,,	562,350	47·9
		1,174,163	

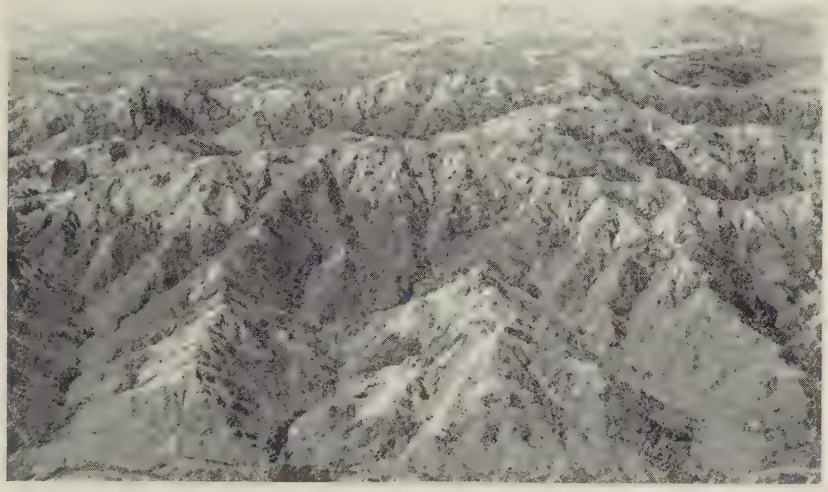

FIG. 50.—Burning and grazing have led to considerable sheet erosion on the Wakarara Hills.

Steep Mountain and Foothills:

The bush and native grasslands of the western ranges and foothills have been burnt and overgrazed with the result that erosion is very active on the steeper greywacke slopes particularly at Wakarara, Ashley Clinton, and on the Kaweka Range.

Exposed soil has been sheet and wind-eroded, with the result that scree creep and gullying have become prominent on northerly and westerly slopes (Fig. 50). On slopes of southerly aspect reversion to manuka and bracken fern is widespread. The increased volume of run-off on this poor grazing country has caused much lateral scouring and sedimentation of river beds.

On the foothills of the Kaweka Range some of the worst eroded land of moderate elevation is found. Exposed ridges and hillsides have been stripped of soil and subsoil, and eroded down to a hard clay or rock surface (Fig. 51). Eroded areas (three to eight feet in depth) occur on gentle slopes and are drained by deeply cut channels which are actively scouring under the influence of frost, wind and rain (Fig. 52). Material washed off is sorted and the residual, coarser sand is readily blown by wind to build dunes found in leeward situations.

FIG. 51.—Farming has resulted in severe wind, sheet and gully erosion, Blowhard.

FIG. 52.—Severe wind funnelling on gentle slopes following burning. Blowhard.

Eroded strips and patches are closely related to routes of access, indicating that the destruction of vegetation and trampling by stock had an important bearing on their inception. There are very few examples of colonization by plants on eroded areas, although numerous "islands" of native flax (*Phormium tenax* and *P. Colensoi*) indicate the resistance of its fibrous roots to erosion, as do overhanging clumps seen on sides of gullies (Fig. 53).

On the higher flat-topped Burns ridge some miles west, the shattered greywacke is overlain by three to four feet of volcanic ash lying on clay (four feet in depth), both of which have been removed from parallel

FIG. 53.—Grazing, trampling and burning exposed the soil to active erosion by wind and water, Kuripapanga.

strips several chains in width. The retreating escarpments were capped by sand dunes (three to five feet in height and eight feet in width) which were moving into the manuka progressively. Advancement into and undermining of the manuka proceeded more rapidly in the sandy upper layers of the soil than in the clay layers beneath. In places stones present in the original clay created a rock pavement that slowed down the rate of erosion and assisted manuka seedlings to establish. Living *Olearia* and broadleaf trees ten feet in height were standing as if on stilts. Six feet of soil had been removed from beneath the base of their trunks leaving the radiating roots to support the trees (Fig. 53). Mount Cameron, on the lower slopes of the Kaweka Range, which carried 12,000 sheep in the '90's is now abandoned. Small remnants of the former native association of grasses are found on southerly faces. The remainder of the area has deteriorated badly, scree slopes being prominent. One particular northerly face, over half a mile in length and 1,200 to 1,500 ft. in height, is now an active scree of shattered greywacke devoid of plants.

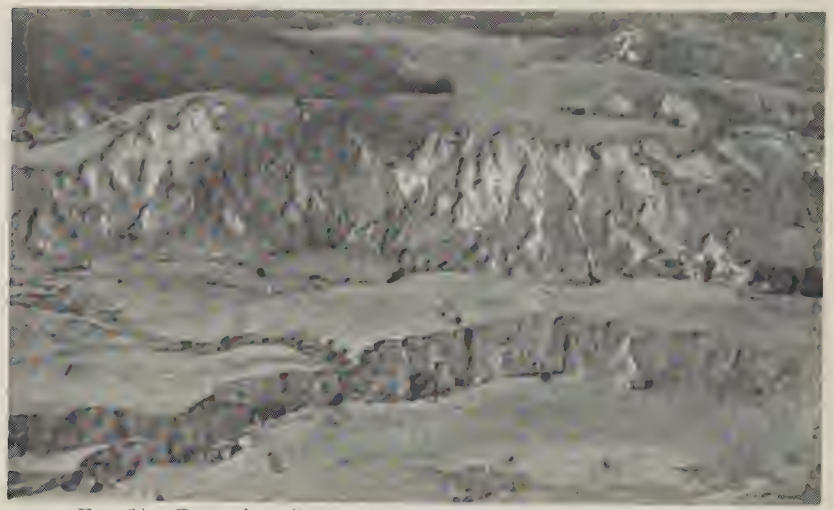

FIG. 54.—Extensive slipping in the Esk headwaters caused by torrential rain, Ap. 1938.

FIG. 55.—Slippage and flowage follow on the removal of the forest, Titiokura.

On the steep southerly escarpment of the Mangaharuru Range between the Napier-Taupo highway and the Esk River much of the surface soil and subsoil has sloughed off slopes cleared from native bush, and the stream channels have been scoured ten to twenty feet deeper in recent times to cause further slipping and slumping (Figs. 54 and 55).

Debris and logs that buried the lower Esk Valley in 1938 came from this part of the catchment and the acres of logs piled three and four deep that have been moved into the river bed by slips are rather ominous. Esk settlers noted that the 1924 rains caused minor slipping that contrasted strongly with the general slipping during the 1938 rains, the first prolonged rains after the 1931 earthquake.

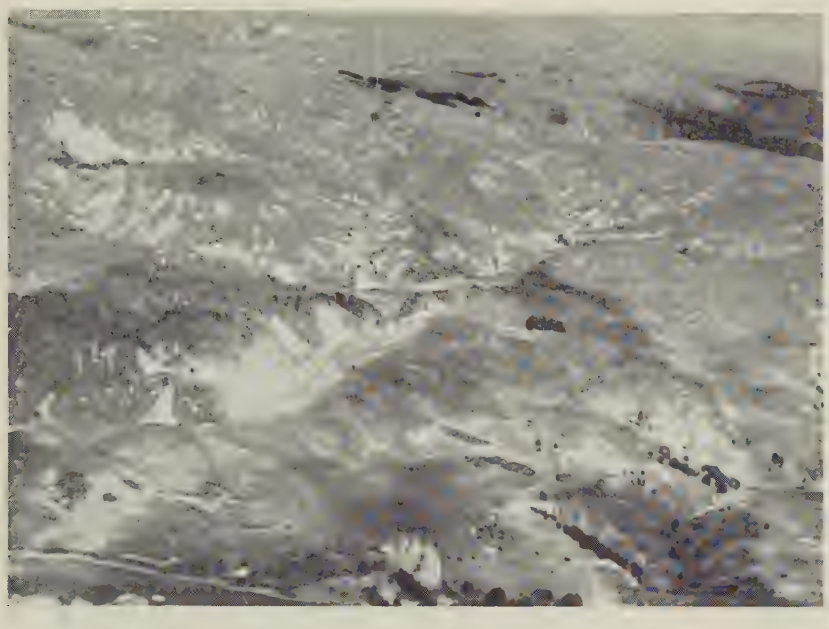

FIG. 56.—Widespread sheet, slip, slump, and gully erosion near Porangahau.

Rolling-to-Steep Coastal Hill Country:

This broad band of fertile rolling-to-steep country carried bush or fern in the early days and was successfully burnt and sown to provide much of the province's best sheep and cattle country.

Sheet erosion has removed much of the topsoil from the steeper northerly slopes and the subsoil is partially exposed in the thin swards of *Danthonia*. More serious, however, is the slip and flow erosion of good pastoral land.

In the southern portion, south of a line between Waipukurau and Porangahau, flowage, gullying and slipping into actively aggrading stream channels is of serious proportions despite the relatively low rainfall (Fig. 56). Some of the most extensively eroded land in New Zealand is to be found in this area while probably more damage has been caused by slipping in the vicinity of Porangahau than anywhere in the Dominion. From here north to Tutira slipping is the common form of mass movement, but farther north, flowage becomes of increasing importance, particularly in the Wairoa area, where both types of movement are common.

The rolling hill country inland and north of Napier is much more severely sheet and slip eroded on northerly slopes than casual inspection reveals (Fig. 57).

Gently Rolling and Alluvial Land:

The central portion of the province, comprising gently rolling hills, the extensive Ruataniwha and Heretaunga plains and the wide valleys of the rivers, has been subject to wind erosion and damage by flooding. Cultivated fields on the Ruataniwha plain have been "blown" in the past by strong winds, but since cropping has been curtailed, and extensive plantations established, such losses are no longer common. Cultivated slopes suffer from sheet and wind erosion while alluvial land is subject to river erosion and flooding.

FIG. 57.—Sheet and slip erosion on northerly slopes—lower Esk catchment.

Extent of Erosion in Mid-Hawke's Bay

As stated by Pohlen and others (47) significant erosion has occurred on the soils over more than half the district while 30 per cent of the remaining area has been affected by flooding and sedimentation. The following tables are of direct interest.

On the mountain areas only 17 per cent can be classified as little eroded.

In its evidence to the Sheep Industry Commission the Hawke's Bay Catchment Board states that 191,590 acres or 15.3 per cent of the District has been subject to sedimentation and flooding since European settlement began.

IMPACT OF FARMING ON THE PHYSICAL AND BIOLOGICAL FORCES

A brief analysis of the impact of farming on the physical and biological forces in the region indicates why soils have become erodible. The extent to which the subsequent interactions of slope, climate and rocks have changed the soil provides basic information on conservation principles.

Geology

The parent rock material of Hawke's Bay is in general of a readily erodible character and geomorphic movements are still active in over-steepening slopes and shattering them by earthquake.

The harder and older greywacke rocks of the western mountain regions (rising to 5,000 ft.) are highly folded and shattered and are actively eroding under the normal erosion cycle owing to steepness, high rainfall, frost and wind. Hence, any factor disturbing the original balance is conducive to accelerated erosion.

In northern portions of the ranges greywacke rocks are overlain by more recent deposits of volcanic ash (Tongariro and Taupo showers) dominantly of a pumiceous character which are very erodible by wind and water when exposed.

The rolling-to-steep coastal hill country consists of parallel bands of limestone, mudstone and sandstone downwarped centrally, with anticlines of soft Tertiary material overlying soft Cretaceous beds exposed in the northern and southern parts of the province.

Loss of stability of these has led to extensive slipping while increased runoff has caused considerable gullying. The alluvial deposits of the central southern terraces and river flats consist of gravels, sands and silts which are readily eroded by active rivers.

In general the geological character of the province predisposes it to active normal erosion which is greatly accentuated when the soil is exposed as a result of burning, grazing and cultivation.

Topography

Rolling-to-steep slopes dominate the topography of Hawke's Bay although this is relieved in the central southern portion of the Province by easy rolling to gently sloping terraces. The drainage pattern of the central and southern portion is dendritic and three major rivers—the Tuki Tuki, Ngaruroro and Tutaekuri—practically converge on the Heretaunga and Ahuriri plains between Hastings and Napier where they are liable to cause flooding. To the north the higher steeper mountain lands are drained principally by the well entrenched Mohaka and Wairoa rivers.

The older uplifted mountain lands to the west with their steep slopes, narrow valleys and steeply graded streams, are still immature topographically.

The more recently uplifted coastal sedimentary hill country is in general not so steep owing to the softer parent material that is prone to slipping and rapid change to more gentle slopes.

The problem of stock concentration on the sunny aspects of slopes and consequent more rapid rate of erosion particularly on convex slopes is not readily overcome even by fencing on country composed of numerous varied slopes each of small area.

Steepness, together with the consequent thin soils, is probably the most important physical factor delimiting farming and causing slope instability and soil erosion under modern conditions. The following table, taken from the bulletin of Pohlen *et al.*, illustrates the percentage distribution of different Slope Classes in the Hawke's Bay area.

PERCENTAGE DISTRIBUTION OF SLOPE CLASSES IN MID HAWKE'S BAY (INCLUDING HERETAUNGA PLAINS). (47)

Slope Class	Per cent.
Very Steep	23·0
Steep	1·8
Moderately steep	21·0
Total (land too steep to plough)	45·8
Rolling	28·6
Flat (higher terraces)	10·3
Flat (low river flats)	15·3
Total (land of ploughable slope)	54·2

Climate

In general the climate is mild and sunny, and the rainfall low to medium over the greater part. The drying westerly wind and very variable rainfall—intense rains alternating with droughts—give character to the climate.

Hawke's Bay depends principally on its rainfall from occasional north-easterly, south-easterly and southerly storms. The mean annual rainfall varies from 25 in. in central areas to over 80 in. near the mountains. Falls of over 10 in. of rain may occur in any month at most stations. The outstanding feature of the rainfall of Hawke's Bay is its variability, which is greater in February and March than in April and is still greater in May. Dr. Kidson (48) states that the rates of fall are sometimes phenomenal while Seelye (16) has recently shown that the greatest percentage variability in annual rainfall in New Zealand is found in the Hawke's Bay-Gisborne area. This highly variable rainfall contributes much to soil erosion and flooding problems in the area.

From May to August the extreme minimum temperatures are low and there is a liability to severe frosts (49).

The wind velocities are sufficient to cause wind erosion particularly on the pumice areas, but also on recently cultivated and finely prepared seed beds over the greater portion of the area.

The combination of drought and windy weather results in increased fire hazard and often severe overgrazing and consequent damage to pastures.

Soils

The rocks, the topography and the climate have had a profound influence on the soil developed in each region and the soils indicate accurately the relative influence of each of these factors. Farming has completely altered the original character of a large proportion of the soils by reducing the capacity of the vegetation to temper the predisposing factors of natural erosion and thus exposing the soil to the direct action of wind and water. With the exception of the heavy alluvial soils the fertility was medium to low, but it is much lower since the soils have become compacted and exhausted of their organic matter and as a result have lost structure and capacity to infiltrate water rapidly. (See Pt. I.)

In Part I it was shown that the erodibility of soils was directly related to soil types, which have been mapped (47).

The Rendzina Group, consisting of soils derived from limestone, is the most fertile. Owing to their good structure these fertile soils are fairly resistant to erosion.

Yellow-grey loams are usually derived from sandstones and mudstones. Soil types of the recent stage lie on very steep slopes and are constantly being renewed by slipping. In general, the immature soils are fertile, while the semi-mature soils range from slightly to strongly acid, and are low in potash and lime. Where the rainfall rises above 60 in. forest is found and the soils are strongly leached. The mudstone soils of this group are susceptible to sheet, slip, flow and gully erosion.

The brown-yellow loam group containing forest soils is prominent on the western and southern portions of the province. These soils are light in texture, low in plant nutrients, particularly phosphate, and are moderately acid. Sheet, wind and slip erosion affect these soils.

The pumice soils are grouped according to the slopes on which they are found and the vegetation under which they have developed. Where forest formerly grew, these soils are more fertile, but this fertility is transient unless maintained by artificial top-dressing. The volcanic pumice soils are very light in texture, moderately acid, and low in bases, phosphate and potash. Pumice soils are liable to wind erosion when cultivated, burnt or over-grazed.

The recent alluvial soils derived from sediments of mudstone, sandstone, and limestone laid down on the flood plains of rivers within comparatively recent times range in texture from heavy clays to sands and stony gravels. These fertile soils are subject to bank erosion and sedimentation by rivers.

In general the thin steep mountain soils under grazing become rapidly exhausted and changed in character to predispose them to sheet, scree and gully erosion.

The pumice soils when exposed by burning, grazing or cultivation are very susceptible to wind erosion and frost lift during winter. The rolling-to-steep soils derived from mudstones and sandstones loose their structure under grazing and burning, and crack deeply in dry weather to induce slipping. The easy rolling downland soils are liable to sheet and wind erosion when exposed unless the fertility is maintained and structure developed to check erosion.

In general, farming has exposed soils partly or wholly by burning, grazing and cultivation for the first time in this long history to wind and water, frost and gravity, and naturally exposed soils have proved to be much more erodible than soils well protected and bonded by vegetation.

Vegetation

There is sufficient historical evidence to indicate that at the time of settlement Hawke's Bay was well clothed by forest, bracken fern, grasses and swamp plants. Beech forest (*Nothofagus* spp.) grew on higher and colder areas while mixed podocarp forest was found on the lower, warmer slopes. There was an extensive though patchy coastal forest dominated by titoki, ngaio, mahoe, broadleaf, hinau and puriri.

In the zone between 30 and 60 in. of rainfall, bracken fern was dominant on the slopes and exposed situations, while Karaka, Nothopanax, Coprosmas, tutu and cabbage trees were found in the gullies

together with a sprinkling of podocarps (remnants of which survive to-day). Where the rainfall was below 30 in. a variety of grasses grew profusely.

Referring to the Hapuka Block which extended eastwards from the Ruataniwha plain, Robert Park (23) described it as "a most valuable one; beautifully diversified by hill and plain; the soil was generally very rich and was nearly all covered with excellent grass".

After mentioning several species of grasses on the Ruahine ranges, Colenso (50) alluded to *Microlena stipoides* "that grew thickly forming pastures on the Hawke's Bay hills," and described "the rusty fern and dingy raupo and pale cutting grass and dry withered plains".

W. B. Rhodes (51) referred to the Heretaunga plain as being mostly clear of fern and as having "no equal for depasturing sheep and cattle in New Zealand".

Sir Donald Maclean (52) described the Ruataniwha plain as "peculiarly adapted for sheep grazing, not luxuriantly covered with verdure, but well clothed with rich grass of every variety."

A considerable portion of the flat land was originally swamp and, according to Colenso, "supported a luxuriant growth of raupo, flax (*Phormium tenax*), niggerhead (*Carex spp.*) and cutting grass (*Arundo conspicua*)" (50). The draining of these ponding areas is probably one of the most significant changes that has been achieved. As the entire area was well clothed with vegetation, erosion was apparently confined to normal geologic rates, while meandering slow-flowing rivers and extensive swamps provided evidence of the balance attained between climate, slope and vegetation in the respective catchments.

The diverse types of native plants have been swept away during the past century and replaced almost entirely by sown grasses which have been established over this wide range of habitat conditions. As fertility declined on the less favourable situations reversion to native grasses (*Danthonia spp.* principally) bracken fern, manuka scrub, and bush has taken place and this reversion is actually continuing on increasing areas that are becoming marginal owing to the limitations imposed by a combination of physical, biotic and economic factors.

By providing protection, developing stability and making possible rapid infiltration, vegetation plays a major role in establishing a stable and enduring soil-plant partnership which is the climax to a long period of interaction between all the components of the landscape. Since this partnership of plants and soil is the fusion product of the physical and biotic forces, it becomes the important erosion-resistant skin of the earth upon which life depends. Where the normal erosion potential is not high, e.g., on gentle slopes, fertile soils, moderate climate and stable parent material, it has been possible to replace the original vegetation and establish a permanent and stable pasture cover under normal farm management. But farming experience in Hawke's Bay has proved that in habitats where one or more of the physical factors is loaded with high erosion potential it has not been possible to bring the induced vegetation and management into a permanent balance with the physical conditions.

The cataclysmal change from diverse and well adapted forest, fern, scrub, grass and swamp plants to grazed pasture has wrought corresponding change in the stability of the soils in the critical habitats. Soil

conservation measures hinge fundamentally on re-establishing or re-generating a stable soil-plant partnership and managing it in such a way that a permanent balance is assured.

Soil Erosion and Flooding

The combined and cumulative effect of farming on the physical and biological forces in accelerating soil erosion, needs little further mention except that attention should be drawn to the importance of grazing, cultivation and burning. In measurements carried out over a limited number of trials (see Part I) the following results were obtained:—

In 10 trials grazing increased run off 6 times and soil loss 35 times.

In eight trials cultivation increased run off 3.3 times and soil loss 44 times.

In six trials burning increased run off 3 times and soil loss 198 times.

The effect of these operations is more pronounced where the natural swamp lands have been drained for farmland and no longer provide temporary storage, to cushion high flows, and increase the time of concentration and thus impede the rush of flood water.

The gravity of these changes is reflected in complementary changes in the regimen of the streams and rivers which with their increased aggrading, bank erosion and flooding provide a measure of the order of magnitude of the changes in various catchments. Floods with new high level peaks have been experienced in all the major rivers—Wairoa, Mohaka, Esk, Tutaekuri, Ngaruroro, Tuki Tuki and Porangahau. The Ngaruroro completely changed its course over a distance of several miles. Shingle has reached the sea in the lower reaches of the Tutaekuri and Tuki Tuki in comparatively recent years, and is rapidly doing so in the Ngaruroro; consequently these rivers are completely changing their character and behaviour.

It appears, therefore, that the accelerated erosion cycle that started in the headwaters is in the process of passing down the river system.

SUMMARY

A brief synthesis of the changes induced and the results achieved by farming focus attention on the points of remedial management.

1. The physical factors responsible for a relatively active normal erosion cycle have singly or in combination proved to be highly conducive to accelerated soil erosion.

2. Vegetation had tempered the combinations of physical factors operating in the various habitats, while complementary plant communities had evolved that were adapted to the varied conditions throughout the province.

3. The varied soils and associated plant communities had developed a relatively stable erosion-resistant partnership peculiar to each of the habitat conditions.

4. There is evidence to show that balance was attained in each part of the catchment and the rivers and swamps were sufficiently mature to indicate that erosion had reached the "geologic norm" a century ago.

5. Farming with its burning, grazing, cultivation and drainage transformed the vegetation violently and this caused violent change in the soil-plant partnership.

6. Deterioration in the vegetative cover and exhaustion of fertility resulted in increasing exposure of the soil to the active agents of soil erosion.

7. Widespread soil erosion, river erosion and flooding symptoms are becoming increasingly evident.

8. Where farm management is in balance with the physical and biological forces there is no soil erosion problem although excessive run-off contributes to flooding.

9. Conservation measures must focus on the cause—mismanagement of the land—and management must be focused on regenerating a stable soil-plant partnership for each region that will effectively buffer the forces of erosion made so potent by the conducive steep slopes, soft rocks, erodible soils and vigorous climate.

Conclusion

The history of eroded areas indicates that soil erosion is the product of one or more of the land use practices discussed. Clearing, burning, overgrazing, trampling and cultivation react on the edaphic factors in such a way that they predispose soils to accelerated erosion. The changed conditions cause the plant cover to deteriorate and the exposed soil is susceptible to accelerated erosion by increased run-off and soil loss, frost activity, wind removal and mass movements.

The soil erosion potential is accentuated by drought, high winds, torrential rain and earthquakes.

Soil erosion has made alarming progress in a relatively short time and it is difficult to postulate the ultimate results, but under present-day conditions the accelerated rate justifies alarm and merits action for concerted control.

References

(37) Guthrie-Smith, H. (1921): "Tutira." Wm. Blackwood & Sons, London, 162-79.
(38) Taylor, N. H. (1945): Soils and Food Production. Proc. N.Z. Soc. Animal Prod., 8-16.
(39) Grange, L. I. (1944): Basic Scheme for Land Classification. *N.Z. J. Sci. and Tech. 26 (Sec. A)*, 136-41.
(40) Bailey, R. W. (1934): Floods and Accelerated Erosion in Northern Utah. *U.S. Dept. Agr., Miscell. Pubn., 196-8.*
(41) Macdonald, Holmes I.: "The Meaning of Soil Erosion." Univ. of Sydney, New South Wales.
(42) Bennett, H. H. and Chapline, W. R. (1928): Soil Erosion a National Menace. *U.S. Dept. Agr. Circular 33,* 33-5.
(43) Stapledon, R. G. (1939): "Agriculture in the 20th Century." Essays on Research, Practice and Organization to be presented to Sir D. Hall. Clarendon Press, Oxford, p. 193.
(44) Calder, G. G. (1938): Regrassing Depleted Tussock Country. *N.Z. J. Agr., 57,* 399-400.
(45) Cockayne, L. (1926): Monograph on N.Z. Beech Forests, Pt. I. *N.Z. State Forest Service Bull. 4,* 46-63.
(46) Lowdermilk, W. C. (1937): "Headwaters Control, and Use." Paper presented at Upstream Engineers' Conf., 1936. U.S. Govt. Printer.
(47) Pohlen, I. J., Harris, C. S. and Raeside, J. D. (1947): "Soils and Some Related Agricultural Aspects of Mid Hawke's Bay. *N.Z. Dept. Sci. and Ind. Res. Bull. 94,* 168-75.
(48) Kidson, E. (1937): Climatic Notes. *Met. Off. Note 17,* 1-17.
(49) *N.Z. Dept. Sci. and Ind. Res., 11th Ann. Rept.* (1937).
(50) Colenso, W.: "An Account of Visits and Crossings over the Ruahine Mountain Range, 1884," pp. 7, 10, 14.
(51) Rhodes, W. B. (1841): *N.Z. Gazette,* p.
(52) Maclean, Donald: Diary, 10th Dec., 1851, Hawke's Bay Museum.

A COMPARISON OF METHODS OF PROGENY TESTING FOR QUANTITATIVE CHARACTERS IN RYEGRASS (*Lolium* sp.)

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Summary

A comparison is made between three systems of progeny testing as a basis of selection for high leaf production in ryegrass: (a) open-pollination of parent plants in an "increase area," (b) diallel crossing, (c) top-crossing to a common plant.

Open-pollination in an "increase area" and diallel crossing provided similar information in 90 per cent. of cases, whilst top-crossing was less consistent.

The advantages of the open-pollination test compared with crossing are discussed.

INTRODUCTION

In the breeding of improved strains of pasture plants the only sound basis for selection is the progeny test which enables selection to be made on the genotype rather than the phenotype of the plant material available. Selection has to be applied to a complex range of physiological and morphological characters. Of prime importance in pasture plants is leaf production which is a complex character embodying leaf size, density, tillering and rapidity of growth. Many other characters of importance in pasture plants are of such a complex nature. The knowledge of the mode of inheritance of such characters is fragmentary but this is clearly quantitative in nature. If selection must be based on the genotype then the question arises as to what type of progeny test should be used; should progenies be obtained by selfing, crossing, or open-pollination? The term "open-pollination" here refers to any crossing system in which the male parent is unknown.

The majority of the pasture species being investigated in New Zealand are cross-fertilized and are highly self-sterile so that methods of progeny testing commonly used in normally self-fertilized plants cannot be applied. In tests on perennial ryegrass (*Lolium perenne*) and Italian ryegrass (*L. multiflorum*) for example, out of 449 and 842 plants self-pollinated the author has obtained 69.5 and 58.2 per cent setting less than one seed per panicle, which would provide insufficient seed for progeny tests. Where sufficient progeny plants can be obtained by selfing, this progeny test is of limited value for the study of such characters as yield, owing to the considerable reduction in vigour brought about by self-fertilization. Jenkin (1) has stated that in perennial ryegrass there is on the average a reduction in vigour of over 40 per cent in the first generation from selfing. The results secured here with both perennial and Italian ryegrass are in agreement with those of Jenkin. Although in a very small percentage of cases there are progenies from selfing which exhibit only a slight reduction in vigour, nevertheless the loss of vigour is in general so large as to render self-pollination impracticable as a method of progeny testing for such characters as leaf production and vigour of growth.

TABLE I. MEAN PLANT WEIGHTS (GRAMS) FOR FIRST CUT OF PROGENIES FROM OPEN-POLLINATION IN AN "INCREASE AREA" AND FROM DIALLEL CROSSING

	Open-pollination.					Crosses.										
Blocks.	A.	B.	C.	D.	E.	AB.	AC.	AD.	AE.	BC.	BD.	BE.	CD.	CE.	DE.	SUM.
I	605·5	559·3	561·1	375·4	380·8	566·9	600·7	420·7	407·9	543·8	398·4	382·4	465·7	381·9	414·5	7065·0
II	540·2	444·7	547·1	419·6	413·6	448·2	549·6	453·7	344·6	458·0	404·6	425·1	407·1	391·8	334·4	6582·3
III	497·8	488·6	520·4	441·3	416·2	508·9	601·1	490·0	347·2	547·5	394·8†	411·3	429·7†	387·9	241·2	6723·9
IV	548·2	452·8	485·3	432·6	465·4	534·6	647·4	518·5	458·9	563·6	422·3†	494·8	457·2†	354·2	300·6	7136·4
SUM	2191·7	1945·4	2113·9	1668·9	1676·0	2058·6	2398·8	1882·9	1558·6	2112·9	1620·1	1713·6	1759·7	1515·8	1290·7	27507·6
$\bar{x}$	547·9	486·4	528·5	417·2	419·0	514·7	599·7	470·7	389·7	528·2	405·0	428·4	439·9	379·0	322·7	

Analysis of variance.

Variation due to.	df.	Sum of squares.	Mean square.	F.
Blocks	3	14195	4732	2·61
Progenies :				
Between open-pollination and crossing	1	13655	13655	7·52**
Between remaining progenies	13	300992	23153	12·75**
Error	38	68990	1816	
Total	55	397832		

Significance of difference between means :— 5 per cent. level :— 60·9 g.
1 per cent. level :— 81·5 g.

NOTE. † Weights obtained by Allen and Wishart's formula for missing items.

In strain building with cross-fertilized plants it is necessary to use a number of unrelated plants as the basis of the synthetic strain to guard against inbreeding. The problem in selecting these individuals is to discover those which show the highest combining ability. That combining ability in grasses is heritable has been shown by Frandsen (3). To progeny test plants for this characteristic recourse must be made to some system of crossing or open-pollination rather than to selfing. Which of these methods to use will depend primarily on their respective reliability as an indication of the genotype of the parent plants but will also depend on the rapidity and ease with which the progeny test can be applied. If several systems of progeny testing are equally reliable then that which is the most easily applied is to be desired, for in attempting to select elite parent material it is advantageous to apply the progeny test to as many plants as time, space and labour will allow.

The investigations reported in this paper were made to compare crossing with open-pollination to provide progeny tests as a basis of selection for high leaf production in ryegrass.

METHODS AND RESULTS

Five plants of short-rotation ryegrass (2), which is a strain bred from hybridization between perennial and Italian ryegrass, were used as parent plants and split into clones. Two plants of the clone of each parent were planted at widely spaced intervals in an "increase area" of short-rotation ryegrass, to provide seed from open-pollination. An "increase area" is a block of approximately an acre planted with seedlings spaced eighteen inches apart, and is harvested to provide a nucleus seed supply of a bred strain. From open-pollination in the "increase area" it would be expected that each of the five parent plants would be pollinated by a fairly similar sample of pollen as the plants comprising the "increase area" originate from only about ten basic plants inter-pollinated.

The five plants were also diallel crossed. The method of crossing was by mutual pollination within transparent cellulose bags without emasculation. It was considered unnecessary to emasculate the plants as self-fertility was low and therefore the percentage of seed set from self-fertilization during mutual pollination would be extremely small. The self-fertility figures for the five plants were 1.9, 1.6, 1.1, 0.1, and 0 per cent.

Seedlings of the five progenies from open-pollination and the ten progenies from diallel crossing were planted on the 6th June 1945 as spaced plants two feet apart. The progenies were planted out in four randomized blocks, each progeny within a block consisting of a row of 30 plants so that there was a total of 120 plants per progeny. Surrounding the block was a guard row of plants.

The plants were grazed by sheep and trimmed occasionally, and were cut and weighed individually on the 7th November 1945 and again on the 22nd March 1946 when differences in persistency between progenies had become apparent. The green herbage weights in Tables I and II are recorded as mean plant weights in grams for each block of thirty plants.

Comparison of the progeny test from open-pollination in the "increase area" with that from inter-crossing.

In Tables I and II are shown the mean plant weights obtained in the first and second cuts respectively from the fifteen progenies. In the

TABLE II. MEAN PLANT WEIGHTS (GRAMS) FOR SECOND CUT OF PROGENIES FROM OPEN-POLLINATION IN AN "INCREASE AREA" AND FROM DIALLEL CROSSING

	Open-pollinations.					Crosses.										
Blocks.	A.	B.	C.	D.	E.	AB.	AC.	AD.	AE.	BC.	BD.	BE.	CD.	CE.	DE.	SUM.
I	169·4	211·8	152·6	64·3	77·8	171·2	202·7	97·3	90·3	188·2	122·2	122·6	79·8	34·9	20·7	1805·8
II	230·5	214·0	176·3	94·1	74·6	240·7	239·5	137·2	120·3	185·7	140·3	115·2	86·6	42·7	21·7	2119·4
III	239·1	282·6	195·7	99·8	61·4	283·5	227·4	127·9	92·4	209·0	150·2†	91·9	102·1†	72·5	11·1	2246·6
IV	280·6	255·3	166·7	71·2	94·2	291·6	258·8	125·6	112·9	240·1	156·7†	114·1	108·7†	45·1	23·3	2344·9
SUM	919·6	963·7	691·3	329·4	308·0	987·0	928·4	488·0	415·9	823·0	569·4	443·8	377·2	195·2	76·8	8516·7
$\bar{x}$	229·9	240·9	172·8	82·4	77·0	246·8	232·1	122·0	104·0	205·8	142·4	111·0	94·3	48·8	19·2	

Analysis of variance.

Variation due to.	df.	Sum of squares.	Mean square.	F.
Blocks	3	11000	3667	7·69**
Progenies :				
Between open-pollination and crossing	1	10440	10440	21·89**
Between remaining progenies	13	302568	23274	48·79**
Error	38	18109	477	
Total	55	342117		

Significance of difference between means :— 5 per cent. level :— 31·2 g.
1 per cent. level :— 41·7 g.

NOTE. † Weights obtained by Allen and Wishart's formula for missing items.

left-hand part of each Table are shown for the five plants, A, B, C, D, and E the mean plant weights of the progenies obtained by open-pollination in the "increase area." The figures in the right-hand portion of the Tables are the mean plant weights of the progenies obtained by diallel crossing these five plants. In the analysis of variance also shown in the Tables the variance due to progenies has been separated into a comparison between open-pollinations and crosses and between remaining progenies. In both Tables there is a significant difference between open-pollinations and crosses. The open-pollination group has a higher mean weight than the group of crosses, which would result if the pollinating plants in the "increase area" were on the average superior to the five plants diallel crossed.

In both Tables it will be seen that there is a significant difference between progenies. In comparing them on the basis of mean plant weights a difference for the first cut of 60.9 g. is significant at the five per cent level, and 82.5 g. at the one per cent level. For the second cut the significant differences are 31.2 g. and 41.7 g. respectively.

In Table III for the first cut and Table IV for the second a comparison is made between pairs of parent plants on the basis of the two kinds of progenies—

(1) Those obtained by open-pollination of each plant in the "increase area."

(2) Those from diallel crossing, grouped so that each of the two compared plants is crossed with the three other plants of the experiment.

For each of these two progeny tests the five parent plants have been compared in pairs in the ten possible combinations. The significance of the difference between the mean plant yields is indicated for each pair. In most cases, when two plants are compared on the basis of progenies from crossing each plant to three common plants the differences are consistent for the three comparisons. Where they are not, it is considered that the relative merit of the parents is indicated by the two consistent differences of the three.

Comparison of the two systems of progeny testing shows very good agreement. Tables III and IV show that in only one case of the ten comparisons, viz., that of plants D and E, do the progeny tests disagree in the evaluation of the parent plants. That based on the individual crosses provides information on the combining ability of the plants used, but as a method of ranking the parent plants on their breeding potentialities it gives little information not provided by the open-pollination progeny test. On the data from both cuts, in nine of the ten comparisons the two methods agree in the evaluation of the parents.

The data in Tables III and IV provide information on a third method of progeny testing, namely, top-crossing. In top-crossing the parent plants to be progeny tested are crossed to a common plant and the progenies so obtained compared to determine the relative value of the several parent plants. If the differences between the progenies from crosses shown in Tables III and IV were consistent it would mean that as much information as to the breeding potentialities of the parent plants would have been obtained from top-crossing as was supplied by crossing each to three plants. Reference to Tables III and IV will show, however, that the results from the two systems are not always consistent. Of the five parents used in these investigations four can be top-crossed to the

TABLE III. COMPARISON BETWEEN PAIRS OF PARENT PLANTS ON THE BASIS OF PROGENY TESTS BY OPEN-POLLINATION IN AN "INCREASE AREA" AND BY CROSSING TO THREE COMMON PLANTS. FOR WEIGHTS OF FIRST CUT

Open-pollinations.				Crosses.					
A	B	d	Sig.†	Cross	$\bar{x}$	Cross	$\bar{x}$	d	Sig.
547·9	486·4	61·5	*	AC	599·7	BC	528·2	71·5	*
				AD	470·7	BD	405·0	65·7	*
				AE	389·7	BE	428·4	—38·7	
A	C								
547·9	528·5	19·4		AB	514·7	CB	528·2	—13·5	
				AD	470·7	CD	439·9	30·8	
				AE	389·7	CE	379·0	10·7	
A	D								
547·9	417·2	130·7	**	AB	514·7	DB	405·0	109·7	**
				AC	599·7	DC	439·9	159·8	**
				AE	389·7	DE	322·7	67·0	*
A	E								
547·9	419·0	128·9	**	AB	514·7	EB	428·4	86·3	**
				AC	599·7	EC	379·0	220·7	**
				AD	470·7	ED	322·7	148·0	**
B	C								
486·4	528·5	—42·1		BA	514·7	CA	599·7	—85·0	**
				BD	405·0	CD	439·9	—34·9	
				BE	428·4	CE	379·0	49·4	
B	D								
486·4	417·2	69·2	*	BA	514·7	DA	470·7	44·0	
				BC	528·2	DC	439·9	88·3	**
				BE	428·4	DE	322·7	105·7	**
B	E								
486·4	419·0	67·4	*	BA	514·7	EA	389·7	125·0	**
				BC	528·2	EC	379·0	149·2	**
				BD	405·0	ED	322·7	82·3	**
C	D								
528·5	417·2	111·3	**	CA	599·7	DA	470·7	129·0	**
				CB	528·2	DB	405·0	123·2	**
				CE	379·0	DE	322·7	56·3	
C	E								
528·5	419·0	109·5	**	CA	599·7	EA	389·7	210·0	**
				CB	528·2	EB	428·4	99·8	**
				CD	439·9	ED	322·7	117·2	**
D	E								
417·2	419·0	—1·8		DA	470·7	EA	389·7	81·0	*
				DB	405·0	EB	428·4	—23·4	
				DC	439·9	EC	379·0	60·9	*

† Difference in mean plant weight of 60·9 g. is significant at 5 per cent. level, and 81·5 g. at 1 per cent. level.

TABLE IV. COMPARISON BETWEEN PAIRS OF PARENT PLANTS ON THE BASIS OF PROGENY TESTS BY OPEN-POLLINATION IN AN "INCREASE AREA" AND BY CROSSING TO THREE COMMON PLANTS. FOR WEIGHTS OF SECOND CUT

Open-pollinations.				Crosses.					
A	B	d	Sig †	Cross	$\bar{x}$	Cross	$\bar{x}$	d	Sig
229·9	240·9	−11·0		AC	232·1	BC	205·8	26·3	
				AD	122·0	BD	142·4	−20·4	
				AE	104·0	BE	111·0	−7·0	
A	C								
229·9	172·8	57·1	**	AB	246·8	CB	205·8	41·0	*
				AD	122·0	CD	94·3	27·7	
				AE	104·0	CE	48·8	55·2	**
A	D								
229·9	82·4	147·5	**	AB	246·8	DB	142·4	104·4	**
				AC	232·1	DC	94·3	137·8	**
				AE	104·0	DE	19·2	84·8	**
A	E								
229·9	77·0	152·9	**	AB	246·8	EB	111·0	135·8	**
				AC	232·1	EC	48·8	183·3	**
				AD	122·0	ED	19·2	102·8	**
B	C								
240·9	172·8	68·1	**	BA	246·8	CA	232·1	14·7	
				BD	142·4	CD	94·3	48·1	**
				BE	111·0	CE	48·8	62·2	**
B	D								
240·9	82·4	158·5	**	BA	246·8	DA	122·0	124·8	**
				BC	205·8	DC	94·3	111·5	**
				BE	111·0	DE	19·2	91·8	**
B	E								
240·9	77·0	163·9	**	BA	246·8	EA	104·0	142·8	**
				BC	205·8	EC	48·8	157·0	**
				BD	142·4	ED	19·2	123·2	**
C	D								
172·8	82·4	90·4	**	CA	232·1	DA	122·0	110·1	**
				CB	205·8	DB	142·4	63·4	**
				CE	48·8	DE	19·2	29·6	
C	E								
172·8	77·0	95·8	**	CA	232·1	EA	104·0	128·1	**
				CB	205·8	EB	111·0	94·8	**
				CD	94·3	ED	19·2	75·1	**
D	E								
82·4	77·0	5·4		DA	122·0	EA	104·0	18·0	
				DB	142·4	EB	111·0	31·4	*
				DC	94·3	EC	48·8	45·5	**

† Difference in mean plant weight of 31·2 g. is significant at 5 per cent. level, and 41·7 g. at 1 per cent. level.

remaining plant and the four progenies so obtained constitute a progeny test for comparison of these four plants. Each of the five parent plants can be used in this way as the top-cross parent for the other plants. When the progenies so obtained are compared in pairs there will be a total of thirty differences between pairs of progenies. If these thirty differences are used to evaluate pairs of parent plants then in five of the thirty comparisons for the first cut (Table III) the results are not consistent with those obtained when the evaluation is based on the progeny test from crossing each parent to three other plants. For the second cut (Table IV) four of thirty comparisons are not consistent. If it is accepted that crossing parent plants to three others is a more reliable method than crossing to one plant, then in 17 per cent of the cases for the first cut and 13 per cent for the second cut top-crossing is not a true indication of the breeding merit of the parent plants. It is in fact rather less reliable than open-pollination in the "increase area," the results from which agreed with those from crossing to three common plants in 90 per cent of the comparisons between parent plants.

The purpose of a progeny test in a plant breeding programme is to provide information on which the tested plants can be ranked as to their potentialities as parents.

Considering the first cut (Table III) the data from the diallel crosses indicate that plants A and C are not significantly different from each other although A is superior to B and all three are superior to D and E, whilst D is better than E.

The open-pollination progeny tests indicate a similar ranking except that plant D is similar to plant E.

To obtain the ranking of the five plants on the basis of all possible top-crosses the data for the diallel crosses in Table III (and Table IV for the second cut) can be grouped so that each of the five plants is used as the top-cross parent for the others. For each top-cross the remaining four plants can be ranked by comparing the four crosses in pairs, giving six comparisons or differences between progenies with a common parent. For all possible top-crosses there will then be thirty comparisons.

With two of the possible top-crosses, namely where C and D are used as the top-cross parents, the ranking of the remaining four parent plants is similar to that from diallel crossing. With the other three plants as the top-cross parents, however, there are inconsistencies in the ranking as compared with that from diallel crossing.

In the data from the second cut (Table IV), from the diallel crosses, plants A and B would be ranked as similar and significantly better than the other three plants. Plant C is superior to plants D and E, and plant D is better than plant E.

From the open-pollinations the ranking is similar except that plant D in this test is equal to rather than superior to plant E.

In the top-crosses, when plants B and C are the top-cross parents the ranking is similar to that from diallel crossing. When the other three plants are used as parents, however, there are inconsistencies in the ranking as indicated by diallel crossing.

In ranking parent plants, the evidence from both cuts indicates that the progeny tests from diallel crossing and from open-pollination in the "increase area" provide very similar information. With top-crossing, however, in the case of three of the five plants used as top-cross parents, the ranking disagrees with that from diallel crossing.

DISCUSSION

Two of the progeny testing methods which have been compared in these investigations—open-pollination in the "increase area" and diallel crossing—provide results which are in agreement in 90 per cent of the comparisons made, whilst the results from top-crossing are less consistent.

An "increase area" of ryegrass consists of a population of plants much less variable than an unselected population but still heterogeneous. If each of the parent plants to be progeny tested by open-pollination in the "increase area" were pollinated in that area by a similar sample of heterogeneous pollen, it would be expected that the progeny test so provided would be comparable with that from crossing the parent plants individually to a heterogenous sample of plants. The results quoted here, where open-pollination in the "increase area" is compared with the crossing of very diverse plants, indicate that similar information is in fact provided by the two methods.

In an extensive breeding programme progeny tests must be made on large numbers of plants and the facility with which these tests can be carried out is an important consideration. In testing plants by the open-pollination technique the number of progenies required will be equal to the number of parent plants; in crossing to only three tester plants three times the number of crosses as there are parent plants will need to be made, necessitating more time, labour, and space. Should a large supply of seed from each plant be required, as for testing each progeny in plots under pasture conditions, the open-pollination progeny test has an obvious advantage over crossing. Furthermore, the technique of crossing is not as simple as that of open-pollination and there is greater chance of errors occurring. However, it may be desired to use progenies not only as a test of the breeding potentialities of parent plants but also to provide material for further selection in strain building. In this case crosses, where both parents are known, are more valuable than open-pollinations where the pollen parents are unknown. The crosses may serve the double purpose of progeny tests and the provision of plant material for further selection. However, if crosses are made with this double purpose there will be very few fortunate combinations of good plants, particularly in the early stages of a breeding programme when there is no indication of the genotype of the plant material. In this case it would be more efficient to sort out those plants of the best genotype by means of an open-pollination progeny test, and then to cross only those proved by this test.

The progeny test from open-pollinating a number of plants together should, like the method of open-pollinating in an "increase area," provide a reliable indication of the breeding potentialities of the parent plants. If there is uniform inter-pollination between the plants in the block, the progeny from each plant should equal the mean of the progenies from crossing that plant to the other plants in the block. In practice, however, where a large number of plants are to be progeny tested it would be difficult to obtain uniform inter-pollination unless a large number of clonal plants of each parent were scattered at random throughout the block. Particularly would this be so with wind-pollinated species where the tendency would be for a plant to be pollinated by adjacent plants. However, the polycross technique as used by

Tysdal, Kiesselbach and Westover (4), Frandsen (3), and Wellensiek (5) has proved a satisfactory method. Here sufficient cuttings of each parent are planted in a polycross block to ensure that each parent is pollinated by most of the other individuals. The results obtained by Frandsen and Frandsen (6) with various grasses show that the method has been effective in indicating clones with the highest combining ability. Tysdal and Crandall (7) have shown in *Medicago sativa* that the performance of polycross progenies is similar to that of progenies from a number of single crosses having a given clone as a common parent. The necessity for random inter-pollination in this progeny test is pointed out by Burton (8), who has suggested a method of obtaining such pollination in polycrosses in *Paspalum notatum.* In an "increase area," however, which consists of progeny plants from perhaps ten or twelve parent plants, the pollen produced from small blocks of plants throughout the area should be fairly similar. Therefore, to ensure random pollination of plants placed therein there would not be the necessity to use as many clonal plants of each as would be required if the parents were open-pollinated in a block.

The value of the progeny test by open-pollination in the "increase area" lies in its simplicity. Its efficiency as a progeny test for quantitative characters in a cross-fertilized species has been indicated in this paper. By its use, particularly in the early stages of a breeding programme, when selection on genotype must be applied to plants previously selected only on phenotype, the plant breeder has a ready means of exploring the breeding potentialities of a large array of plant material.

Acknowledgments

The writer is indebted to Mr. J. M. Todd who supervised the technical work connected with the investigation.

References

(1) Jenkin, T. J. (1931): *Imp. Bur. Plant Genetics, Herbage Plants,* Bull. 3.

(2) Corkill, L. (1945): *N.Z. J. Agr., 71,* 465-70.

(3) Frandsen, H. N. (1940): *Imp. Agr. Bur. Joint Pubn., 3,* 80-92.

(4) Tysdal, H. M., Kiesselbach, T. A. and Westover, H. L. (1942): *Nebr. Agr. Exp. Sta. Res. Bull.,* 124.

(5) Wellensiek, S. J. (1947): *Medelingen Landbouwhogeschool, 48* (7), 227-62.

(6) Frandsen, H. N. and Frandsen, K. J. (1948): *Nord. Jordbrforskn Nos. 7-8,* 239-61.

(7) Tysdal, H. M. and Crandall, B. H. (1948): *J. Am. Soc. Agron., 40,* 293-306.

(8) Burton, G. W. (1948): *J. Am. Soc. Agron., 40,* 470-2.

SUPERFICIAL SCALD ON NEW ZEALAND GRANNY SMITH APPLES—THE PERIOD OF GREATEST SUSCEPTIBILITY

By C. A. S. PADFIELD, Fruit Research Station, Department of Scientific and Industrial Research, Havelock North

Summary

A series of wrapping treatments carried out on Granny Smith apples during the first 24 weeks of cool-storage showed that irrespective of fruit maturity, scald susceptibility increased from the first to the twelfth week and thereafter decreased until the twenty-fourth week.

INTRODUCTION

During 1941 preliminary experiments on the gas-storage of Granny Smith apples were undertaken. The results were very disappointing in that every apple under trial suffered from superficial scald. Before continuing this gas-storage work, it was decided to carry out some investigations on superficial scald under cool-storage conditions.

Part of this programme was an experiment carried out on lines similar to those adopted by Kidd and West (1934), who worked on the variety, Newton Wonder. Its purpose was to determine the period of greatest scald susceptibility.

EXPERIMENTAL

The experiment was carried out during the 1942 and 1943 storage seasons, using fruit from Hawke's Bay. This fruit was picked at two stages of maturity, pickings being timed a month apart, with the second picking coinciding with the normal commercial picking period. The fruit was held throughout the experiment at a temperature of 33-34°F. A series ot wrapping treatments of three weeks duration was carried out over the first 24 weeks of storage, by dividing each picking into two sets of eight samples.

In Set I, each of the eight samples was successively left unwrapped for one period of three weeks. Conversely, in Set 2, each of the samples

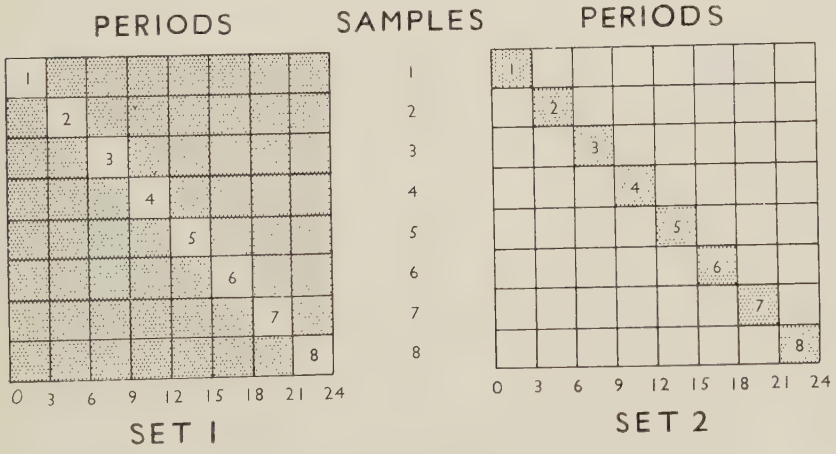

FIG. 1.—Granny Smith wrapping periods, shaded squares indicate periods when fruit was wrapped.

TABLE I. 1942—TOTAL PERCENTAGE OF SUPERFICIAL SCALD ON REMOVAL FROM COOL-STORE

	1st Pick.				2nd Pick.			
Picking Date.	25/3/42.				27/4/42.			
Storage Date.	27/3/42.				30/4/42.			
	Set 1.		Set 2.		Set 1.		Set 2.	
Date of Examination.	20/1/43.		5/11/42.		20/1/43.		7/12/42.	
Period of Storage.	296 Days.		245 Days.		263 Days.		221 Days.	
Period of Treatment.	No. of Apples.	Scald %	No. of Apples.	Scald %	No. of Apples.	Scald %	No. of Apples.	Scald %
0 to 3 weeks	261	65	262	52	261	7	262	81
3 ,, 6 ,,	262	58	257	48	262	21	261	77
6 ,, 9 ,,	259	64	262	33	263	13	263	43
9 ,, 12 ,,	262	71	262	13	256	38	263	31
12 ,, 15 ,,	263	46	262	16	262	14	261	20
15 ,, 18 ,,	263	70	263	27	263	44	261	26
18 ,, 21 ,,	263	68	263	51	259	19	262	43
21 ,, 24 ,,	263	51	262	65	262	20	261	53

TABLE II. 1943—TOTAL PERCENTAGES OF SCALD ON REMOVAL FROM COOL-STORE

	1st Pick.				2nd Pick.			
Picking Date.	22/3/43.				18/4/43.			
Storage Date.	26/3/43.				22/4/43.			
	Set 1.		Set 2.		Set 1.		Set 2.	
Date of Examination.	4/1/44.		4/9/43.		25/1/44.		23/1/44.	
Period of Storage.	284 Days.		172 Days.		277 Days.		215 Days.	
Period of Treatment.	No. of Apples.	Scald %	No. of Apples.	Scald %	No. of Apples.	Scald %	No. of Apples.	Scald %
0 to 3 weeks	138	71	138	57	137	15	138	70
3 ,, 6 ,,	138	61	137	61	138	52	138	72
6 ,, 9 ,,	138	59	136	36	137	70	138	59
9 ,, 12 ,,	136	74	138	27	138	42	138	20
12 ,, 15 ,,	136	60	138	40	136	51	136	29
15 ,, 18 ,,	136	57	137	55	138	39	138	41
18 ,, 21 ,,	137	76	137	71	136	37	138	74
21 ,, 24 ,,	137	61	137	79	135	50	138	78

was wrapped for a similar period as shown in Fig. 1. Samples consisted of two bushel cases in 1942 and one bushel case in 1943.

At the end of each period the wraps were renewed on all samples in Set 1, except on the particular sample which was to be left unwrapped. This procedure was adopted so that no sample would receive any advantage from having new wrappers applied.

Commercial oiled wrappers containing not less than 15 per cent mineral oil by weight were used throughout the experiment.

As at the end of 24 weeks no scald had appeared, all the fruit was re-wrapped in new paper and remained in storage until some scald had appeared on all samples in each set. It was then removed and each apple examined for scald.

DISCUSSION OF RESULTS

Tables I and II present picking, storage and examination dates, together with the period of storage and the total percentage of scald on each sample.

A comparison of examination dates shows that for apples of similar maturity the period of storage for Set I, was longer than for Set 2, indicating that scalding was delayed by the more continuous coverage by oiled wraps during the treatment period.

In 1942, both sets of the first picking were held for longer periods than their corresponding sets of the second picking, suggesting that fruit of advanced maturity scalds more quickly than immature fruit. This result was not confirmed in 1943, as it applied only to first sets of each picking, the reverse being true of the second sets.

Examinations took place at different times, so that it was not possible to gauge the true effect of maturity on scald. An indication was given in 1942, when Set 1 of both pickings was examined on the same day. Results showed that the period of maximum susceptibility was the same in each set, but less scald was recorded on the second picking.

Percentages of scald were very irregular in both years for Set 1 of both pickings and no general pattern of scald susceptibility was obtained from the results. This irregularity indicated that three weeks was not long enough to leave fruit unwrapped, in order to produce significant differences in scald susceptibility.

In the Set 2, serious scald induction took place during the treatment period in both pickings and in both years, even though scald did not appear for a considerable time after treatments had been completed. In three of the sets scald susceptibility increased from the first to the twelfth week and decreased again from the thirteenth to the twenty-fourth week.

In the fourth set, 2nd Pick Set 2 1942, the increase was continued until the fifteenth week and decreased thereafter.

REFERENCES

KIDD, F. and WEST C. (1934) : *Gt. Brit. Dept. Sci. and Ind. Res. Food Investigation Board Ann. Rept.,* 110-4.

BOOK REVIEW

WOOL RESEARCH, 1918-1948. VOL. 6: DRAWING AND SPINNING

WOOL INDUSTRIES RESEARCH ASSOCIATION, LEEDS. Pp. 225 + vii. 1949. 21/-

The Wool Industries Research Association has planned to publish a series of eleven volumes under the title "Wool Research 1918-1948" so as to give a complete account of the researches which the Association has conducted during the first thirty years of its existence. Vol. 6—Drawing and Spinning—is the second in this series to be published, its predecessor being Volume 4—Carding.

Judging from the first two volumes, it is certain that, providing this standard is maintained, the whole series will prove to be invaluable to members of the industry, technicians, teachers, and research workers, and should do much to bridge the existing gap between wool research and the wool textile industry.

Chapters 1 and 2 of this volume deal with the evolution of drawing and spinning machinery, and of the worsted drawing process showing how machines and methods evolved from the times of the earliest civilizations. The author has met with considerable success, both in the presentation and illustration of these two chapters which serve as a historical introduction to the following twelve chapters.

Each of Chapters 3 to 13 deals with some aspect of the technology of worsted drawing and spinning, giving theoretical considerations, together with accounts of the investigations which have been made by the Association. A valuable feature of these chapters is that the opportunity has been taken in many cases to review the results and conclusions of the earlier investigations in the light of modern knowledge and experience, and a comparison has been made with the results of more recent investigations in which modern technique and testing methods have been employed. The earlier investigations have thus been brought up to date.

The final chapter, Chapter 14, reviewing existing methods and recent trends in research is found to be particularly interesting in view of the revolutionary changes which are now taking place in worsted drawing and spinning through a better understanding of the fundamentals of fibre manipulation, and the adoption of new machine methods.

The volume is concluded with an appendix on the roller drafting of woollen slubbing.

The authors have written in a clear and easily understandable manner, and have maintained a practical outlook throughout, which adds much to the value of a publication of this nature.

The illustrations are particularly good, and the quality of production is of a high standard.

—G. A. C.

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